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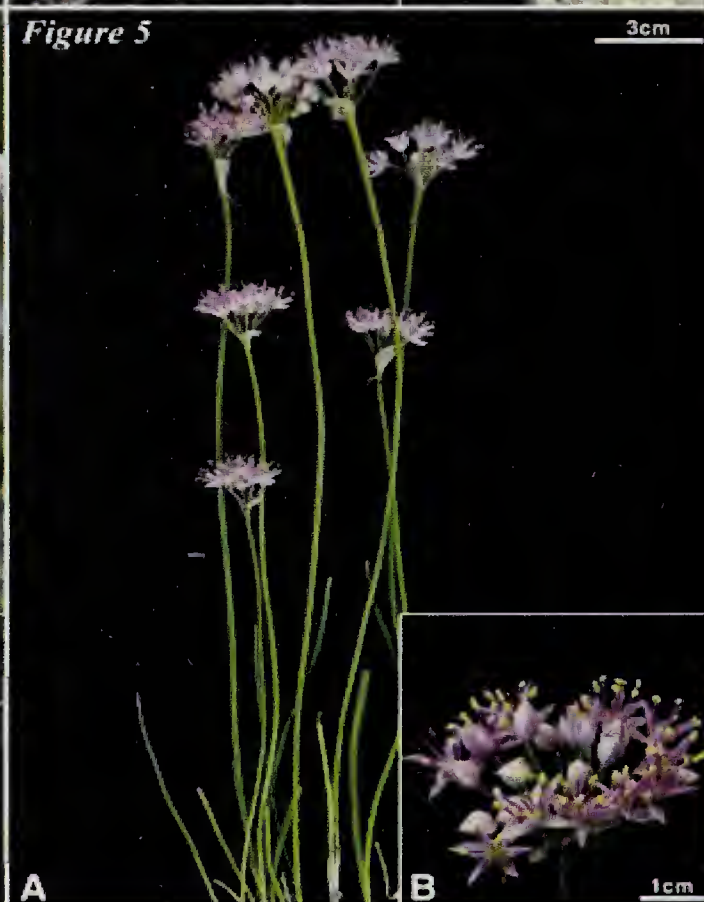
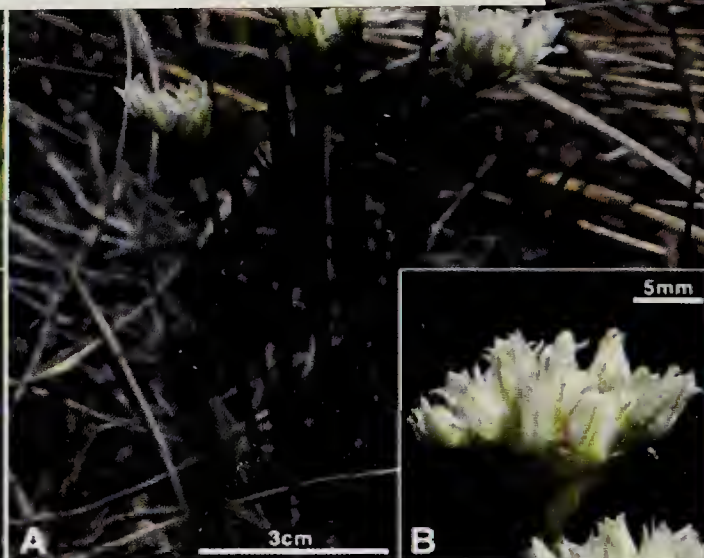






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Figure



Figures 2–5. *Allium* species in Saskatchewan. 2. *A. schoenoprasum*; 3. *A. textile*; 4. *A. cernuum*; 5. *A. stellatum*. A) Plant habit; B) Inflorescence. See article by Choi et al. on p. 146.

**Front cover:** Black-footed ferret (*Mustela nigripes*) in a black-tailed prairie dog (*Cynomys ludovicianus*) colony in Grasslands National Park, Saskatchewan. For more on the reintroduction of black-footed ferrets to Canada, see article by Wruth et al. on p. 133.

Patrick McManus

**Back cover:** Jumping spider, possibly *Phidippus borealis*. See Photo Note by H. Schmidt on p. 166.

Harvey Schmidt

# Blue Jay

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## NOTABLE RECORDS FROM THE MANITOBA BREEDING BIRD ATLAS 2010 SEASON

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After many years of dreaming and more than a year of detailed preparations, 2010 saw the much-anticipated first year of data collection for the Manitoba Breeding Bird Atlas. This project will have 5 years of data collection (2010–2014), and volunteers are being sought to cover all areas of the province. The Atlas follows a similar protocol to those used for several other completed or ongoing provincial breeding bird atlases.<sup>1</sup> Mapping is based on a grid of over 7000 squares (10 km × 10 km), divided into 14 administrative regions (Fig. 1) and a set of criteria that define observations as “observed” only or as “possible,” “probable,” or “confirmed” breeding records. This article summarises the most noteworthy breeding-season records gathered by Atlas volunteers and crew in 2010. Since data entry is not yet complete, this article will only briefly discuss general trends noted (up-to-date summary statistics can be viewed at: <www.birdatlas.mb.ca>). A meeting to review unusual records was held in Winnipeg on 16 August 2010, and this article refers primarily to records reported before that date.

### Exceptional Breeding Season Records

Three of the season’s most significant records involved members of the family Cardinalidae, as recently expanded by the North American Classification Committee of the American Ornithologists Union (AOU) to include the *Piranga* tanagers (see <<http://www.aou.org/checklist/north/>>). Scientific names of all birds mentioned in this article can also be found at the AOU website.).

At least one adult male black-headed grosbeak has held a singing territory annually in the same patch of riparian woodland along the Souris River south of Melita since 2006 (K. De Smet et al.). There were some reports of a subadult male and probably also a female present in at least one of those years. On the evening of 15 June 2010, Ken De Smet observed the male feeding nestlings in a nest 2 m above the ground in a tall shrub just inside the woodland from the roadside ditch edge. Although there are as many as 40 records (mostly migrants, and many unconfirmed) in Manitoba, this

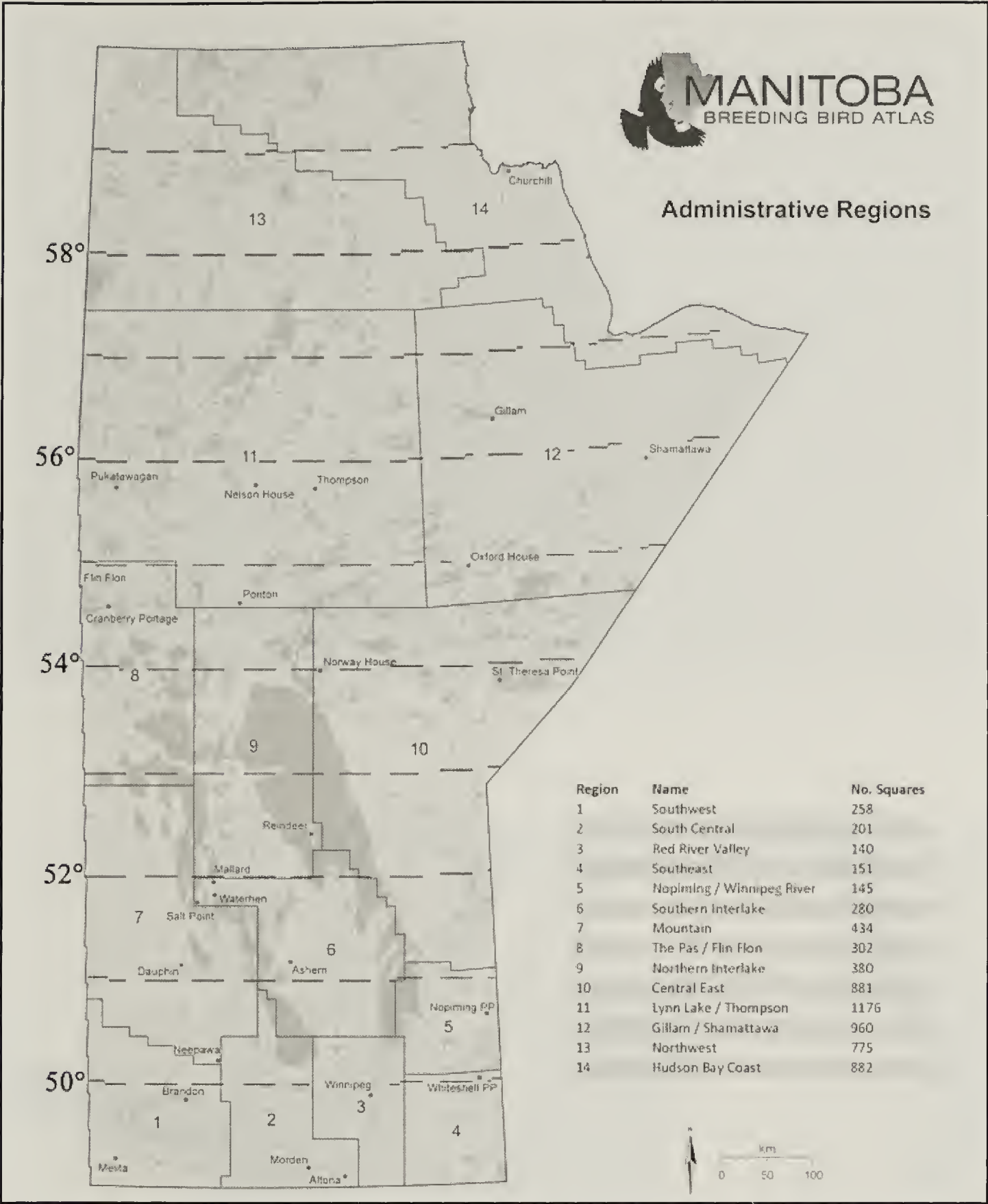


Figure 1. Administrative regions (n = 14) of the Manitoba Breeding Bird Atlas.

is the first confirmed breeding attempt of this species in the province.<sup>2</sup> The female was not seen on the above date, nor on any occasion in 2010, so it is not known whether this is a hybrid pair (i.e., black-headed × rose-breasted); rose-breasted grosbeaks occur regularly in the same area (Fig. 2).

Western tanager is another western species that has been suspected of breeding in Manitoba but never confirmed.<sup>2</sup> On 5 June, David Raitt found a pair, as well as an unpaired male, while atlassing in the Root Lake area north of The Pas. Although he did not find a nest, his subsequent observations of both adults





Figure 2. Rose-breasted grosbeak.

Linda Boys



Figure 3. Western tanager north of The Pas, Manitoba, 12 June 2010.

David Raitt

carrying food that was not for their own consumption indicated that they probably had young in the area (Fig. 3).

Wayne and Gloria Tingey observed a male lazuli bunting visiting a seed feeder on their property along the Antler River southeast of Lyleton on 25 May. Although it visited the feeder only sporadically, this bird was subsequently heard and seen by several observers on the Tingey's property. Repeat observations from late May until early July, all within 200 m of the house (W. & G. Tingey, R. Porteous), and observations on 20 July (K. De Smet) and on 30 July (C. Artuso & J. Swartz; Fig. 4, see inside back cover, top) suggest that this bird remained on territory in an area with sparse riparian woodland and overgrown weedy fields. It used the same song perches repeatedly, in particular the uppermost dead branches that emerged above the foliage of two living Manitoba maples (*Acer negundo*), within an area of 0.85 ha, alternating between them for non-continuous song bouts lasting as long as 13 min (C. Artuso). Gloria Tingey reported seeing a female *Passerina* bunting earlier in the nesting season that she believed had the markings of a female lazuli; however, it was not seen regularly at the feeder, nor was it seen later in the season by other observers. Although this species occurs regularly in southeast Saskatchewan, there are fewer than 30 sightings in Manitoba, and breeding has never been confirmed.<sup>2</sup>

Equally notable to the three cardinalid records was the discovery of a recently fledged family of four young green herons at a Steinbach golf course on 19–20 August (R. Reimer) and confirmed by several other observers. This discovery followed sightings of two adults earlier in the month (H. Lane). While the species has been recorded about 100 times in Manitoba, this is only the second confirmed breeding record for the province.<sup>2</sup>

## Improved Definition of Northern Range

With the notable exception of coastal regions near Churchill, there remains much to learn about bird distribution in central and northern Manitoba, especially north of a diagonal line running northwest-to-southeast from about The Pas to Bissett. One of the key aims of the Atlas is to improve the definition of these limits beyond what proved possible in *The Birds of Manitoba*.<sup>2</sup> This should provide a more reliable reference against which to detect future changes that may arise, for example, from habitat alteration and climate change.

While some farmland species, such as western meadowlark, reach boundaries that are sharply defined by the extent of agricultural development, the range limits for most forest and wetland birds are diffuse and much more difficult to define than most published range maps might seem to suggest. This is equally true with the southern range limits of northern birds, the northern limits of southern birds, and all boundaries for those species restricted to the boreal forest. This problem is compounded by difficulty of access and low human population density, which result in very limited historical knowledge of boreal bird distribution, since isolated pockets of habitat are often inaccessible and rarely if ever visited by birders or professional ornithologists.

Volunteers and field crew in western Manitoba recorded several species that are associated primarily with the Aspen Parkland in areas north of their expected ranges (Table 1). American woodcock was recorded above 51.3° N in both the Interlake and the Duck Mountains; however, this species was recently recorded as far as 52.7° N in the Porcupine Hills and 53.0° N just south of Grand Rapids (C. Artuso, unpublished).<sup>2</sup> The single record of warbling vireo 25



km southwest of The Pas was heard only (J. Kayer). Veery was recorded in three squares in Region 8 (The Pas / Flin Flon), the northernmost being near Goose Lake, approximately 15 km south of Cranberry Portage, and in eight squares in the Porcupine Hills, but not in Region 9 (northern Interlake). The gray catbird found approximately 20 km north of The Pas (D. Raitt) was at a similar latitude to a recent Breeding Bird Survey record at Minago River (P. Taylor). Additional species recorded near The Pas, towards the northern periphery of their ranges, include wood duck, marbled godwit, and sedge wren (many observers). Some of these species have been found in recent years in areas modified for agriculture in the Carrot Valley and around Ralls Island (D. Raitt). Recent surveys by Bird Studies Canada have found other unexpected species in the Porcupine Hills area, including chimney swift near Barrows, yellow-throated vireo near Whitefish Lake, and indigo bunting near Birch River (C. Artuso, unpublished).

The most notable record from Manitoba's Interlake region was a singing male pine warbler found on 19 June at 52°N in suitable breeding habitat – an extensive, mature jack pine (*Pinus banksiana*) stand near Highway 6 south of Tan Creek (P. Taylor). Further exploration for the species in this area is planned. Although there are a few previous records of migrant pine warblers away from their known breeding range in southeast Manitoba, including two fall records on Hecla Island (19 August 2002, G. Holland; 2 September 2002, A. Courcelles), this is apparently the first territorial bird recorded in the Interlake during the breeding season. Northern parula was found in at least five locations in the Interlake in 2010, including three singing males close to 53°N (Katimik Lake, P. Taylor; Long Point, P. Goossen and R. Mooi; and near Grand Rapids, R. Mooi), providing

further evidence of a breeding population in central western Manitoba, as recently described.<sup>3</sup> Eastern bluebirds were found in at least four locations north of their principal range including three Atlas squares in the central/northern Interlake (Region 9) and also near The Pas. The north–south highway and transmission-line corridors and associated structures in the Interlake region seem to have provided an opening for this species; a pair was found breeding at Ponton (54.6°N) in 2007.<sup>4</sup>

Turkey vulture was recorded near Thompson (R. Koes and R. Staniforth), well north of the known breeding range, but in keeping with scattered reports north of 53°N in recent years, possibly involving wandering subadults. A singing winter wren was exceptionally far north near Twin Lakes, southeast of Churchill (R. Koes). In a visit to Dunlop's Fly-In Fishing Lodge at Waskauiwaka Lake, north of Split Lake, from 10 to 17 July, Rudolf Koes and Richard Staniforth found several species north of their expected ranges. American white pelicans were recorded in various sections of Waskauiwaka Lake, although these may have been wandering non-breeders or long-range commuters from distant colonies. Common grackles were recorded much farther north than expected in seven Atlas grid squares in this same region, including four confirmed breeding records. Red-winged blackbirds were recorded in five squares, including three instances of fledged young. Other unexpected finds around Waskauiwaka Lake were black-capped chickadees (in five squares), hairy woodpecker, least flycatcher, and red-eyed vireo. Black-billed magpies are known to occasionally irrupt northward into the boreal forest,<sup>2</sup> but a family group with five young, photographed by Brian Taylor at Paint Lake (55.5°N) on 2 August, was still a surprise.



**Table 1.** Notable northern records from summer 2010. Calculations of distance from expected range are based on maps drawn in *Birds of Manitoba* that indicate “regular breeding”, not including those areas where the species is described as “rare migrant or visitor”.<sup>2</sup> Only the northernmost records for each of the following areas are given: W (western Manitoba), I (Interlake), and N (northern Manitoba), as indicated in Column 2. Elsewhere in the table, N. = north / northern. Atlas codes are X: bird observed in breeding season but not in normal nesting habitat (level = observed); H: bird in breeding habitat and S: bird singing (level = possible breeding); A: agitated behaviour, M: more than seven singing males detected in one square on one day, P: pair (level = probable breeding); FY: fledged young, CF: carrying food not for own consumption (level = confirmed breeding). An asterisk (\*) beside a code indicates that this was the highest code for the given Atlas region.

Species	Locality	°N	Distance from known range. <sup>2</sup>	Observer(s)	Code
American white pelican	Waskaiowaka Lake (N)	56.5	150 km N.	R. Koes, R. Staniforth	X*
American woodcock	Grahamdale (I)	51.4	N. edge of range	P. Taylor	H
	Duck Mountains (W)	51.3	N. edge of range	A. Stone	H
Black-billed cuckoo	Proulx Lake (I)	51.8	N. edge of range	P. Taylor	M*
	Duck Mountains (W)	51.6	N. edge of range	J. Willans	S*
Whip-poor-will	The Pas (W)	54.1	N. edge of range	D. Raitt	S*
Hairy woodpecker	Waskaiowaka Lake (N)	56.5	N. edge of range	R. Koes, R. Staniforth	P*
Least flycatcher	Waskaiowaka Lake (N)	56.5	N. edge of range	R. Koes, R. Staniforth	S*
Great crested flycatcher	Porcupine Hills (W)	52.6	N. edge of range	A. Stone	S*
Red-eyed vireo	Waskaiowaka Lake (N)	56.5	N. edge of range	R. Koes, R. Staniforth	S*
Warbling vireo	The Pas (W)	53.6	N. edge of range	J. Kayer	S*
Black-capped chickadee	Waskaiowaka Lake (N)	56.5	200 km N.	R. Koes, R. Staniforth	S*
Winter wren	Churchill (N)	58.7	250 km N.	R. Koes	S*
Marsh wren	Katimik and Kaweenakumik Lakes (I)	52.9	100 km N.	P. Taylor	S*
Eastern bluebird	The Pas (W)	53.6	200 km N.	J. Kayer	CF*
	Grand Rapids (I)	53.3	150 km N.	J. Kayer	A
Veery	Cranberry Portage (W)	54.4	50 km N.	J. Kayer	S*
Gray catbird	The Pas (W)	53.9	200 km N.	D. Raitt	S*
	Long Point (I)	52.9	125 km N.	D. Raitt	H*
Pine warbler	Tan Creek (I)	52.0	200 km N.	P. Taylor	S*
Northern parula	Grand Rapids (I)	53.1	150 km N.	R. Mooi	S*
Red-winged blackbird	Waskaiowaka Lake (N)	56.5	150 km N.	R. Koes, R. Staniforth	FY
Common grackle	Waskaiowaka Lake (N)	56.5	100 km N.	R. Koes, R. Staniforth	P



## Southern Range Extensions

Much fewer southward than northward apparent range extensions were detected, which is not surprising given the much better knowledge of bird distribution in the more populous south, and perhaps also a greater potential for range contraction near the southern fringes of the boreal forest.<sup>5</sup> Nevertheless, the comments about limited coverage of the boreal forest also apply to extreme southeast Manitoba, and there is potential for surprises just an hour's drive east of Winnipeg.

One of the most notable southern range extensions recorded in 2010 occurred when Vic Reimer found a nest of Bonaparte's gull, approximately 7.5 m high in a black spruce, on 16 June at Windy Lake (northeast of Richer at 49.7°N). This is easily 200 km south of the species' expected breeding range. Rudolf Koes and Richard Staniforth found a pair of tundra swans with two cygnets at Waskaiowaka Lake, over 200 km southwest of the nearest known breeding locations near the Hudson Bay coast. Interestingly, both Bonaparte's gull and tundra swan have recently been recorded breeding far south of their expected ranges in Saskatchewan.<sup>6,7</sup>

A fox sparrow was recorded as probably breeding about 20 km north of The Pas, based on repeated observations of a singing individual in suitable habitat (D. Raitt). This is the third year in a row that singing fox sparrows have been encountered in this area. In 2009, seven were heard singing from presumed territories, and one nest with four young was located on 16 June 2009. White-crowned sparrows were recorded in eight locations around Waskaiowaka Lake, including recently fledged young, and both common redpoll and Bohemian waxwing were also found there (R. Koes, R. Staniforth). This is along the very southern periphery of these species' known ranges.

## Declines and Disappearances

One of the more difficult topics that the Atlas, by virtue of its intensive coverage, will help address is the current distribution of grassland species that appear to be experiencing range collapse in Manitoba. The ranges of grassland specialists such as burrowing owl, Sprague's pipit, Baird's sparrow, grasshopper sparrow and chestnut-collared longspur extended, as recently as the 1980s, to the easternmost edge of the greater prairie ecosystem in Manitoba. Sprague's pipit and grasshopper sparrow even occurred, albeit with patchy distribution, in parts of the boreal transition zone with long-standing agricultural development. These species have usually only been recorded in extreme western Manitoba since the 1990s. The situation is different with ferruginous hawks, which had become quite rare by the 1920s and thereafter went unreported until a few were seen in the extreme southwest in the 1970s and nesting was confirmed in the early 1980s.<sup>2,8</sup> Happily, since then a small nesting population has persisted in the southwest.

In 2010, a grant from Environment Canada's Habitat Stewardship Program permitted a crew of three to undertake intensive fieldwork in mixed grass prairie and fescue prairie in the northern portion of Region 1 (north of the Trans Canada Highway) and the southern portion of Region 7, mostly south of Riding Mountain National Park. This work complemented the grassland bird monitoring and management conducted annually since the 1980s Manitoba Conservation (K. De Smet) in the southwest corner of the province.

The vast majority of the 2010 records of Manitoba's grassland specialists came from Region 1. Following an extremely successful nesting season in 2009, when all but one of 35 pairs produced young,



ferruginous hawks increased to 41 nesting pairs in 2010, including two nests south of Glenboro on the eastern edge of Region 1 (K. De Smet). Although fewer than half of these pairs produced young, two dark-morph females in the southwest each successfully raised at least one dark-morph young. Five burrowing owl nests were found (down from nine in 2009) including three in extreme southwestern Manitoba, one near Cartwright, and one north of Wawanesa (K. De Smet et al.). This species was formerly recorded locally as far east as the Winnipeg area;<sup>2</sup> however, it seemed to disappear from the province between the late 1990s and 2006 (K. De Smet).

Three grassland sparrow species most strongly associated with native and native-like grasslands in Manitoba – Baird's sparrow, grasshopper sparrow and chestnut-collared longspur – are now largely confined to the westernmost areas of Region 1. Of these, the grasshopper sparrow normally ranges farther east and north; in 2010, territorial individuals were recorded in three squares in Region 2, north of St. Claude (C. Braden), near Mariapolis (K. De Smet), and near Mather (L. Veelma), and one was found in southern Region 7 near Cracknell, west of Riding Mountain National Park (N. Melnycky). A report of a pair of grasshopper sparrows feeding young near Whytewold in the southern Interlake (C. McPherson) was convincing but not confirmed. Baird's sparrows were recorded in only a few squares in the extreme southwest, in the Pipestone–Lyleton area and along the “blind Souris River” valley south of Melita to the U.S. border (K. De Smet). The only record of Baird's sparrow outside the extreme southwest was one heard on 7 July on a plateau with suitable native prairie and some shrubs above the eastern bank of the Assiniboine River west of Lenore (M. Prill); however, two subsequent attempts

to find this individual were unsuccessful. Chestnut-collared longspur observations in 2010 were largely confined to the same range as Baird's sparrow (see above), but a population also persists in the St. Lazare area near the Assiniboine River in extreme western Manitoba (C. Artuso et al.). There was also a single observation of several birds on territory in native prairie between Shilo and Brandon (K. De Smet). Although both chestnut-collared longspur and Sprague's pipit were recorded in Alonsa Wildlife Management Area east of the Riding Mountains in 2009, none was observed there this year, perhaps due to poor weather conditions and difficulty of access.

Despite wet conditions and reduced surveys in the traditional southwestern monitoring and management area, Sprague's pipits were found in about 200 sites altogether. These included over 100 locations north of the Trans Canada Highway, as far north as Asessippi Provincial Park, with a concentration in the Ellice-Archie community pasture near St. Lazare (C. Artuso et al.). A few were observed as far east as the Shilo-Brandon area (K. De Smet, R. Koes). Many were found in grazed tame pasture habitat, although numbers are probably greater in native-like haylands and pastures. None was found in areas of former occurrence east of Regions 1 and 7.<sup>2</sup> Nonetheless, Sprague's pipits are still much more widespread in Manitoba than either chestnut-collared longspur or Baird's sparrow.

A loggerhead shrike photographed in a remnant patch of native prairie near Glen Elmo just south of the westernmost part of Riding Mountain National Park on 27 June was exceptional (C. Artuso, J. Spallin). In recent years there have been occasional observations of shrikes in other areas well north of the Trans Canada Highway, e.g., in the Neepawa-Eden area. Nesting



observations during 2010 were primarily restricted to the extreme southwest, south and west of Pipestone; even there, fewer than 40 pairs were noted, marking a steep decline in the last 20 years (K. De Smet). An additional three presumed pairs were observed in the Brandon-Shilo region (K. De Smet). The plight of the eastern loggerhead shrike (race *migrans*) in the Winnipeg area also appears dire, as numbers have been steadily decreasing from a dozen breeding pairs in 2000 to one pair in 2009 and no known breeding records in 2010 (K. De Smet, R. Porteous).

### Other Notes

Eurasian collared-doves are extending their range into Manitoba more slowly than they did in Saskatchewan, but they continued to increase, being reported in 2010 in at least nine locations across southern Manitoba, all south of the 50th parallel, from Lyleton in the southwest (many observers) to Whitemouth in the southeast (W. Jansen). Excluding sightings of spring transients, trumpeter swans were reported from four locations, near Steinbach (V. Reimer), near Whytewold (C. McPherson), in Churchill (R. Koes), and a pair north of Powerview (F. Machovec). Northern mockingbirds were found carrying nesting material in two locations, near Pierson (C. Artuso, J. Swartz) and at St.-Georges (S. Labossière). There was one record of dickcissel, a singing male near Waskada (K. De Smet), one of only a handful recorded in Manitoba since an irruption in 2003 and a post-irruption “echo” in 2004.

While forests were tinder-dry in parts of the north, the summer of 2010 was extremely wet in many parts of southern Manitoba, with several towns experiencing record rainfalls and some such as Emerson being forced to declare

states of emergency after downpours.<sup>9</sup> Environment Canada’s Brandon weather station recorded 152 mm of rain in May, over three times the long-term average of 50.1 mm.<sup>10</sup> Data for June and July have not been published yet, but these were also very wet months. Consequently, sedge wren (238 atlas squares reporting this species before 16 August), Le Conte’s sparrow (233 squares), Nelson’s sparrow (73 squares), and yellow rail (41 squares) were all recorded in high numbers and in many unusual locations such as flooded pastures. Yellow rails call more frequently in daylight hours than is generally realised, and many were recorded during routine atlassing activities. Of special interest, yellow rails were heard regularly at several locations within the city of Winnipeg, with up to six singing individuals present in one small area along the Harte Trail in Charleswood (many observers). Virginia rails were observed with fledged young in Winnipeg (S. Oikawa) and Kleefeld (D. Fast); the species is rarely encountered at these locations. Conversely, both yellow and Virginia rails proved relatively difficult to find in some boreal marshes, presumably because of the wetland bounty elsewhere, and possibly also due to displacement from traditional areas by high water levels.

The Manitoba Breeding Bird Atlas has an extraordinary capacity to engage volunteers of all skill levels. With sufficient participation, this project will greatly augment current knowledge of bird distribution and abundance in Manitoba. Out-of-province volunteers are especially welcome, particularly for collaboration with Manitoba birders and researchers to improve coverage in remote areas of central and northern Manitoba. If you might be able to get involved in any way, please either register via the website or contact the authors.



## Acknowledgements

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*"If a man walks in the woods for love of them half of each day, he is in danger of being regarded as a loafer. But if he spends his days as a speculator, shearing off those woods and making the earth bald before her time, he is deemed an industrious and enterprising citizen."*

*-Henry David Thoreau*

# NEST SITE USE AND BREEDING SUCCESS OF CHIMNEY SWIFTS IN ST. ADOLPHE, MB, 2007–2009

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Chimney swifts (*Chaetura pelagica*) are gregarious insectivores distinguished by a cigar-shaped body and long, tapered wings that extend well beyond the short, bristled rectrices (Fig. 1).<sup>1</sup> After migrating north from their wintering grounds in the upper Amazon basin,<sup>1</sup> chimney swifts arrive in southern Manitoba in mid- to late May.<sup>2</sup> In this area, immature birds and non-breeding adults roost communally at night throughout the summer.<sup>1</sup> Pairs of mature adults breed in sites that contain only one nest.<sup>1, 3</sup>

The Manitoba Chimney Swift Initiative (MCSI)<sup>4</sup> was formed in 2006 to address issues related to the reduced populations of chimney swifts in Manitoba<sup>2</sup> and monitoring of chimney swift nest sites started in the spring of 2007. The

precipitous decline of chimney swift populations nationally has resulted in this species being listed in the spring of 2009 as ‘Threatened’ on Schedule 1 of the federal *Species at Risk Act*.<sup>1</sup> Continued monitoring of the chimney swift population in Manitoba,<sup>4</sup> elsewhere in Canada,<sup>5</sup> and the United States<sup>6</sup> is fundamental to the recovery potential of the species.

Historically, chimney swifts nested in natural tree cavities and perhaps some populations do so even now.<sup>1,2</sup> Once European settlers removed old growth trees and established buildings, chimney swifts began nesting in chimneys.<sup>2</sup> Nests are constructed of small twigs that are glued with sticky saliva to rough, interior surfaces, a considerable distance below a chimney rim.

Presently, chimney swifts typically breed in urban settings in eastern North America, from Texas and Florida through to southern Manitoba and southeastern Saskatchewan.<sup>1,2,7</sup> Near the northern periphery of their geographical distribution, breeding adults establish nests in old brick chimneys on four historic buildings along Main St. in St. Adolphe, MB (49° 40' 27" N, 97° 6' 38" W; 15 km south of Winnipeg). These nest sites were observed in 2007 to 2009 as part of the MCSI monitoring program.<sup>4</sup> Nest site use



Figure 1. A trio of chimney swifts in flight. This photo illustrates the wing shape, the classic “cigar-shaped” body, and the “V” display of the bird at the far left.

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by chimney swifts in Manitoba has not been monitored prior to this study.

Here we present the phenology of nest site use, behaviour of breeding adults, and breeding data collected for St. Adolphe nest sites in 2007 to 2009. We compare characteristics of nesting chimney swifts in Manitoba to southern locations in their range.

## Methods

Five nest chimneys in St. Adolphe were identified in four different Main St. buildings situated in close proximity: Le Club Amical, Brodeur Bros. Ltd., St. Adolphe Catholic Church, and a private residence. In Le Club Amical, two brick chimneys that have not been used for heating for over 20 years are located in the two-storey structure, which was constructed in 1914. The chimneys are about 10 m apart in the southeast (SE) and northeast (NE) corners of the building. The SE Club Amical chimney was used as a nest site in 2009 only. Another nest site occupied for the first time in 2009 was in the two-storey Brodeur Bros. Ltd. car dealership (built in 1932), located ~90 m north of Le Club Amical. The chimney is used seasonally for an oil burning furnace. The St. Adolphe Catholic Church chimney, built in 1913, is due north (~100 m) of Brodeur Bros. The church has a high vaulted roof, and the chimney extends well above it. The church chimney has not been used for heating purposes for decades. The fifth nest site is in a 1918-constructed, private two-storey home on the west side of Main St., across from the church. The chimney, identified as the "Main St. chimney" has not been in service since 1995. It is about 95 m from the Brodeur Bros. chimney and 100 m away from the church chimney. All five nest chimneys are within 200 m of the Red River.

Each year, data collection spanned

the entire time during which the chimney swifts were in St. Adolphe, from spring arrival through to late summer migration. Two observation periods were used: roosting hour and daytime. Roosting hour observations occurred from 30 min prior to sunset to 30 min after sunset; however, severe weather or heavy cloud cover and premature darkness resulted in some shorter observation periods. Daytime observations occurred any other time and were typically 60 min long but varied from 20 to 120 min. Due to the location of nests deep within the chimneys, we could not observe nests, but observed entries and exits of birds from the chimney. Main St. and Brodeur Bros. chimneys have accessible cleanouts and were inspected to verify nesting activity at the end of the breeding season.

Roosting hour (at least weekly) and daytime observations (at least weekly, up to twice daily) always followed the same monitoring protocol. One or more chimneys were observed and the times of entries and exits were recorded to the nearest second. Entry and exit times yielded four intervals: 1) between consecutive entries; 2) between an entry and an exit, referred to as the "duration in the chimney", or the "turnaround time" for partner change-ups; 3) between consecutive exits; and 4) between an exit and an entry, referred to as the "between-visit" interval. The number of chimney swifts using a chimney was derived from the total number of entries versus exits, adjusted for consecutive use, e.g., entry followed by exit followed by entry = 2 entries – 1 exit = at least 1 bird used the chimney; entry followed by entry followed by exit indicated that two birds used the chimney.

In 2008 and 2009, we also recorded the behaviour of individuals entering the chimneys and the group size of approaching or departing chimney



*Figure 2. Chimney swift in flight. The short tail and moulting indicate that this is an adult.*  
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swifts. Trailing wing edges and notching observed on some occasions indicated moulting in adults (Fig. 2),<sup>3</sup> whereas juveniles had complete, continuous wing edges. We identified fledglings by their low, relatively straight flight paths, and slow speed despite rapid wing beats. They generally had their tails lowered and fanned in a “flaps-down” position.

Five nesting stages were identified using our observations (see Results): 1) spring arrival; 2) start of nest building – characterized by exits from the chimney during the day, other than the first morning departure, and exits early in the roosting hour; 3) incubation; 4) feeding brooded and non-brooded young; and 5) fledging, which is followed by a pre-migratory phase and then migration. Previous, direct observations of chimney swift nests in artificial towers provided information on the duration of behaviours associated with various nesting stages in Texas<sup>3</sup> and New York.<sup>8</sup> We used those studies to retrospectively interpret our intervals and durations to identify transitions from one nesting stage to another. Stages of nesting activity were identified, and the phenology, viz. the dates on which these events were first observed, was recorded. We were unable to document ongoing nest building and egg laying.

Successful nesting was confirmed by the identification of fledglings, coupled

with an increased number of roosting chimney swifts. Unsuccessful nesting was indicated initially by reduced activity in the chimney or abandonment of the site. A nest was considered to have failed after at least three consecutive observation periods, including one combined daytime/roosting hour viewing, where no daytime activity was recorded.

## Results

Approximately 350 h of observations were made. In 2007, observations began on 16 May when birds were already present, and ended on 22 August, 10 d after the last bird was observed. In 2008, observations began on 13 May and the first bird was seen on 17 May. The last bird was seen on 2 September and observations ceased on 4 September. In 2009, observations started 11 May and the first bird was seen on 21 May. Observations ended on 1 September, 5 d after the last bird was seen.

Eleven nesting attempts were recorded (Table 1) representing an occupancy rate of 73% over three seasons in the five chimneys. Due to the late date of first identifying the Main St. chimney in 2007 and early departures from the area that year, the outcome for that nest is unknown. Of the ten other nesting attempts, successful fledging was observed at four nest sites producing eight fledged juveniles (Table 1). All successful nests were started by a pair of chimney swifts before the end of May, and in no instance did helper birds assist in the nest building or rearing of young. Three or more consecutive entries/exits in the daytime would have indicated the presence of helpers.

Six of the ten nesting attempts failed (Table 1). In 2007, two adult chimney swifts were trapped in the church for approximately 5 d. Although the birds were caught and released successfully



**Table 1. Phenology of chimney swift nest sites in St. Adolphe, Manitoba, 2007 to 2009. Unless otherwise indicated, arrival dates are based on when a pair arrived.**

Year	Site	Arrival	Nest building	Incubation	Feed brooded juveniles	Feed non brooded juveniles	Fledge date (n fledged)	Departure
2007	NE Club	May 16	May 16-27	June 11	July 4	July 7	July 27-Aug 1 (3)	Aug 13-19
	Amical Church	June 3	Failed Aug 3. Day use ended, continued roosting					Aug 14-22
	Main St.	July 26				July 26	Unknown	~Aug 15
2008	NE Club	May 14-17	May 17-27	June 19	July 9	Failed July 13		Aug 13
	Amical Church	May 18	May 27-29	June 11	July 3	July 10-13	July 31 (2)	Sept 2
	Main St.	May 18 n=1 June 17 n=1	May 30 Failed July 18-21	June 30				July 31-Aug 5
	SE Club	June 13-17	June 17-19	June 30-July 2 Failed July 21. Day use ended, continued roosting				Aug 14
	Amical							
	NE Cub	May 19-26	May 19-26	June 9-13	July 2-8	July 16	Aug 4 (2)	Aug 11
	Amical							
	Brodeur Bros.	June 19	~June 19	July 10-16. Failed July 26. Day use ended, continued roosting				Aug 3-6
	Church	May 11-21	May 29-June 2	June 3-7	June 26-July 13	July 18-20	Aug 1 (1)	Aug 28
	Main St.	May 21 n=1 June 2-7 n=1	May 24	June 30-July 3	July 17-19	July 24-25 Failed July 29-30		July 31

(J. Brodeur, M. Lagasse, G. Michaud, pers. comm.), this interruption probably contributed to the nesting failure. After their release around 11 July, chimney swifts were not active in the church until 18 July, when daytime activity resembling nest building and incubation started. However, daytime use ceased, without fledglings being observed, on 3 August.

The NE Club Amical 2008 nest that was initiated in May failed in July following an intense rain storm. The Main St. home owners verified that the other 2008 failure did not involve nest slippage. Although these birds appeared to be incubating, the nest was empty, and no eggs or bodies were recovered from the cleanout; thus, the cause of abandonment in mid-July is

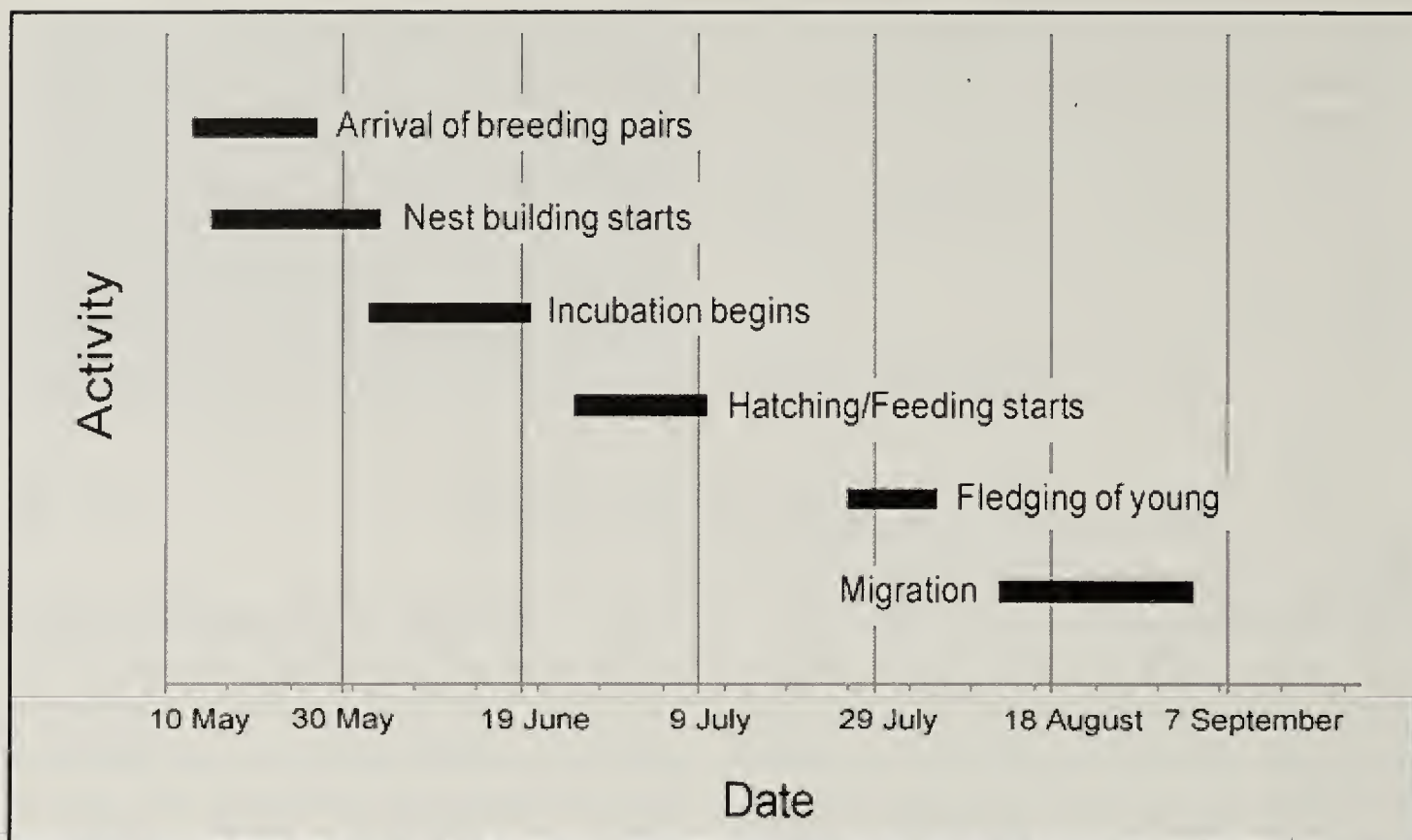


Figure 3. Range of dates for the first observation of different nesting stages for pairs of chimney swifts arriving at St. Adolphe, Manitoba, in May (2007 to 2009).

unknown. In 2009, abrupt cessation of daytime use at Brodeur Bros. indicated that the nest had been abandoned, although the adults continued to roost there. Intact eggs, but no nest, were found in the cleanout at the bottom of the chimney at the end of August. Similarly, debris and remains of dead young at the bottom of the Main St. chimney in August 2009 indicated that not only had the nest fallen off the chimney, probably killing a 10- to 11-day-old juvenile but another juvenile, ~2 d old, had fallen or been ejected previously from the nest. Also, two chimney swifts left the SE Club Amical chimney and were trapped in a closet around 17 June 2009. One bird died and one was released. Subsequently, an adult pair continued with a nesting attempt that failed, likely at the incubation stage.

Two patterns of adult behaviour associated with nest loss were evident. The first pattern involved a gradual decline of daytime use then a relocation of the adults to a different roost. This pattern appeared to be associated with the loss of juveniles (e.g., Main St. nest in 2009).

The other pattern was characterized by the abrupt abandonment of the nest site during the daytime, although adults continued to roost there at night.

The phenology of successful nest sites was used to identify the seasonal pattern of the various nesting stages (Table 1, Fig. 3).

1. **Arrival.** Pairs typically entered the chimney once, within a few minutes of each other, during the roosting hour to rest for the night.
2. **Nest building.** Pairs of chimney swifts entered and exited the chimney during the roosting hour or slightly before. Daytime visits also occurred. Chimney swifts did not always travel in pairs but often entered or exited the chimney individually. The duration in the chimney and the between-visit interval both varied considerably, from 1 to 70 min and from 1 to 50 min, respectively.
3. **Incubation.** The adults took turns on the nest during incubation,<sup>3</sup> and in St. Adolphe, partner exchanges were



quick. Turnaround times were often less than 30 seconds, and one or two change-ups per hour were typical. Usually, one attending adult was in the chimney, but there were short unattended periods, often around dusk.

4. **a) Feeding brooded juveniles.** After a feeding, an adult Chimney Swift will brood or cover the nestlings to keep them warm.<sup>3</sup> In St. Adolphe, nest site use became more active at this stage. Two entries and two exits within an hour, with quick adult turnaround times of ~1 min, were typical in early July.
- b) Feeding non-brooded juveniles.** Juveniles do not require brooding by their parents after 6 to 7 d of age.<sup>3</sup> Adults may simply move to the wall

beside the nest and not leave the chimney,<sup>8</sup> or both adults may forage concurrently to meet the increasing energetic demands of the juveniles.<sup>3</sup> An unattended chimney, indicated by consecutive entries or exits, was a sign of the non-brooding phase. In St. Adolphe, the time young were unattended increased as the juveniles aged (e.g., from 2 min with ~7-day-old chicks to 16 min with ~26-day-old chicks). However, the best indicator of advancing juvenile age was the increased frequency of entries/exits, typically four entries and four exits per hour. The between-visit intervals were variable, 1 to 17 min, as the adult chimney swifts sometimes used the chimney in bursts separated by lulls.

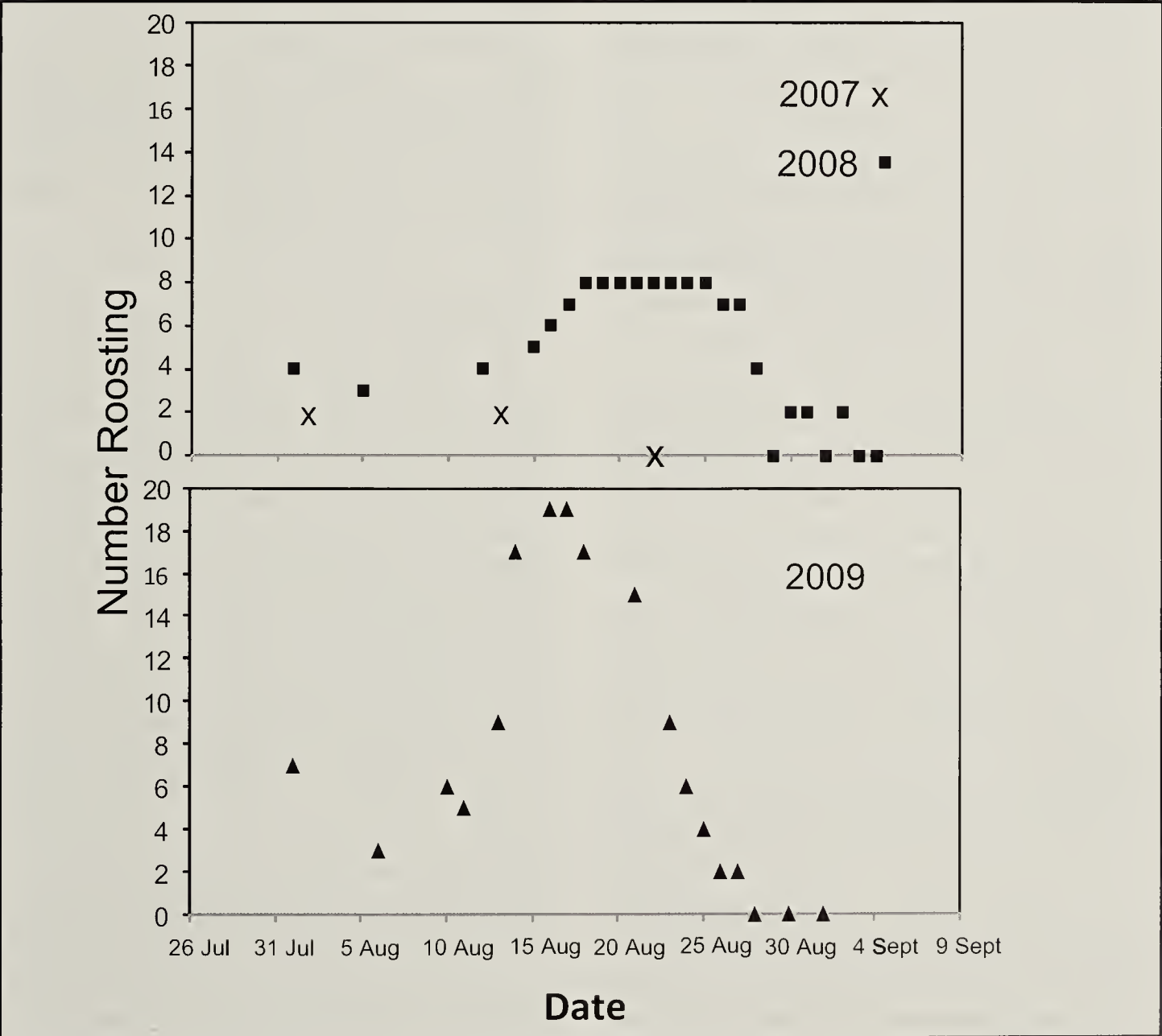


Figure 4. Total counts of chimney swifts roosting at a church in St. Adolphe, Manitoba, in August and September 2007 to 2009.

5. **Fledging.** Fledging was determined when juveniles were identified flying for the first time. In some cases, the adults made many entries and exits just before the young fledged e.g., eight entries and eight exits in 1 h with turnaround times of several minutes.

After juveniles started flying, the number of chimney swifts seen together in the air was at a maximum (Fig. 4) and they were highly vocal. Groups of juveniles and their attending adults flew at low levels in the corridor between Club Amical and the church and over the adjacent fields to the east. Juveniles entered chimneys to rest during the day, using their own natal chimney and other local chimneys.

Daytime entry/exit patterns were variable during the fledging period (e.g., NE Club Amical; fledging day 4 August 2009; 13 entries, 11 exits; 08:47 to 10:02 h). Not only were fledglings moving among chimneys, but both adults, which still feed the young at this stage,<sup>3</sup> entered and exited the natal chimney during the day. Also, some adults that were unsuccessful in their nesting attempt relocated.

- **Pre-migratory phase.** Local birds moved among chimneys during the day and roosting hour. Local movements all took place by 15 August. At this time, group sizes seen in the air were smaller as the birds ranged farther away from the nest site area to feed (Fig. 4). Consequently, there was less daytime use of chimneys in the 7 to 10 d after fledging compared to earlier stages.
- **Migratory phase.** When the total known population of local adult and juvenile chimney swifts was exceeded by roosting birds, it was obvious that some migrants had arrived. Roosting hour counts at the church indicated aggregations of local and migrant chimney swifts (Fig. 4). Chimney swifts entered the chimney singly or in small

groups, during or slightly before, the roosting hour. We interpreted repeated flyovers with veer-offs preceding a halting, foot-first entry as a migrant's first use of an unfamiliar chimney. Late in the season, exits from the chimney were rare and usually were followed by a quick re-entry. After the numbers of roosting chimney swifts peaked, the dispersal of migrating birds eventually reduced roosting counts to zero (Fig. 4).

Migratory patterns varied among years (Fig. 4). In 2007, all birds appeared to disperse by mid-August without forming any local groups. In 2008, a small, local roosting group assembled at the church when the other nest sites were abandoned; then migration started as reflected in the decline of roosting birds (Fig. 4). In 2009, local chimney swifts congregated to roost at the church and were joined by migratory birds. Peak numbers of chimney swifts in 2009 exceeded those of 2008.

## Discussion

Chimney swifts continue to construct nests well into the egg-laying and incubation stages. In general, the birds take an average of 18 d and up to 30 d to build a nest,<sup>7</sup> but egg laying may begin as early as 3 to 7 d into the construction period.<sup>3,7</sup> Incubation is shared by both adults and starts when the second-last egg is laid;<sup>1,3,7</sup> however, nest building continues until the first egg hatches.<sup>3,7</sup> Once the first juvenile emerges, all nest building stops and adults tend their young.<sup>3</sup> Toward the southern edge of the breeding range near Austin, Texas (30° 16' 1" N 97° 44' 35" W), incubation lasts 18 to 21 d, feeding brooded juveniles lasts for 6 to 7 d after hatching, and feeding non-brooded juveniles then extends another 21 to 24 d until the young are 28 to 30 d of age.<sup>3</sup> Therefore, there is normal variation in the time from start of incubating eggs



to fledging of young (minimally  $18 + 28 = 46$  d to, maximally,  $21 + 30 = 51$  d). Chimney swifts nesting in New York in 2009 had similar durations of incubation and feeding.<sup>8</sup> Previously, there have been no comparable data on the duration of nesting stages, and intervals between them, for chimney swifts in Manitoba. This study adds to the three nest records on file for Manitoba.<sup>2</sup>

Chimney swifts from various geographic locations appear to have similar durations of incubation and feeding young. However, differences exist for the intervals between the time of arrival, the onset of nest building, and the start of incubation in various locations. In New York, there was a lag of approximately 4 wk between arrival and the start of nest building, plus an interval of 5 wk between the onset of nest building and incubation.<sup>8</sup> Similar time lags are inferred for Texas (arrive mid-March, nest May through August, depart mid- to late October).<sup>3</sup> In contrast, nest building in Manitoba was initiated within 1 wk of arrival at the nest site; the interval between the start of nest building and incubation was approximately 1 to 3 wk. Chimney swifts in Texas may raise two broods per season,<sup>3</sup> but in New York<sup>8</sup> and Manitoba, one brood is raised.<sup>1, this study</sup> Eight weeks were required for nest building through to fledging. An additional 2 wk were required before migratory movements began in mid-August. The variation in patterns of daily nest use may reflect variance in precipitation and temperature in addition to the variation due to developmental stages of the juveniles.<sup>9–11</sup>

Clutch sizes of two to seven are reported for Austin, Texas,<sup>3</sup> while three to five are typical in Glenham, New York,<sup>8</sup> and Macomb, Illinois ( $40^{\circ} 27' 33''$  N  $90^{\circ} 40' 18''$  W).<sup>12</sup> At St. Adolphe, Manitoba, fledgling counts are a proxy for clutch size, with the number of fledglings per

nest observed to range from one to three. However, four intact eggs were recovered from the Brodeur Bros. chimney in 2009, suggesting that clutch size might be higher than the number of fledglings observed.

Abandonment seemed indicative of nest loss at earlier nesting stages. For example, intact eggs (Brodeur Bros. 2009) and an empty nest (Main St. 2008) were found, suggesting that these nests failed during incubation or before egg laying, respectively. Hatching to fledging takes about 1 mo, and all successful fledging occurred between 27 July and 4 August in St. Adolphe, so eggs being incubated in mid-July are severely time-constrained. In two cases, a chimney containing non-brooded young was scrutinized<sup>3</sup> intensely the evening preceding the sudden abandonment of the late nests.

Daytime monitoring is essential to distinguish roosts from nest sites. Early in the breeding season, pairs of chimney swifts establish their territory in chimneys.<sup>3</sup> Late-arriving birds attempting to roost at a nest site may be displaced by the resident pair. The baseline number of adults (breeding pair + helpers)<sup>3</sup> tending a nest must be established prior to fledging to calculate the number of juveniles fledged. When juvenile chimney swifts are identified during the day, roosting hour observations made the same night will identify an increase in the number of roosting birds. Fledglings may enter the chimney before the roosting hour to rest for the night, so a longer period of observation prior to sunset is advantageous.

## Summary

Not all chimney sites in St. Adolphe, MB, were used by chimney swifts every year. Only one nesting attempt was made per season per pair, and the number of fledged birds was  $\leq 3$ . Nest site use

and breeding success differed in some respects compared to southern locations in the chimney swifts' breeding range. While the duration of incubation and feeding stages in St. Adolphe appeared consistent with birds at the southern end of the distribution, the time between arrival and the onset of nest building, then incubation, was considerably shorter in Manitoba. There was a high rate of nest failure in chimney swifts breeding at the northern periphery of the distribution. Also, the constraints involved for chimney swifts breeding in Manitoba, including such factors as time, rates of nest building, feeding strategies, and weather, warrant investigation.

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# MAMMALS

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## BLACK-FOOTED FERRET REINTRODUCTION IN GRASSLANDS NATIONAL PARK, SASKATCHEWAN

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Once found throughout the Great Plains, the black-footed ferret (*Mustela nigripes*) is a species of international concern and is considered one of North America's most endangered mammals. These native ferrets are small, weasel-like mammals with a black mask, black feet, and a slender buff-coloured body measuring 55–60 cm in length, including the black-tipped tail (Fig. 1). Like most mustelids, black-footed ferrets are primarily solitary and nocturnal. These predators are adapted to survive underground in the burrows of their primary prey, prairie dogs (*Cynomys* spp.).<sup>1,2</sup>

Black-footed ferrets suffered a rapid population decline in the early 1900s, caused in part by human activity (cultivation of habitat, prairie dog eradication programs) and by diseases (sylvatic plague, rabies, canine distemper).<sup>2,3</sup> Black-footed ferrets were thought to be globally extinct until 1981,

when a small population was discovered near Meeteetse, Wyoming. Between 1985 and 1987, the remaining 18 wild black-footed ferrets were captured in an attempt to develop a conservation breeding program to save the species. All ferrets living in the wild today were raised in this program or are the descendants of re-introduced ferrets.<sup>2,3</sup> The Toronto Zoo has participated in the black-footed ferret conservation breeding program for the last 16 years, adding a Canadian component to international ferret recovery efforts.<sup>4</sup>

Historically present on the plains of southern Alberta and Saskatchewan, black-footed ferrets were last seen in Canada in 1937 and were designated extirpated in 1978.<sup>4</sup> The West Block of Grasslands National Park of Canada (GNPC), together with neighbouring community pastures and private ranches, is the best hope for black-footed ferret reintroduction because it is the only place in Canada where black-tailed prairie dog (*C. ludovicianus*) colonies occur.<sup>5</sup> Active prairie dog colonies provide critical habitat necessary for black-footed ferret survival.<sup>6</sup> Prairie dogs comprise about 90% of a ferret's diet,<sup>7</sup> and their burrows provide ferrets with shelter from predators and severe weather and a place to rear young.<sup>5</sup> Recovering black-footed ferrets in Canada will contribute to the North



Figure 1. Black-footed ferret.  
Paul Knaga, Parks Canada

American ferret conservation efforts by re-establishing a wild ferret population at the northern extent of their historic range.

Parks Canada, along with a dynamic and diverse team, has been working to return black-footed ferrets since 2004. The Recovery Strategy for the black-footed ferret in Canada<sup>6</sup> and the Management Plan for the black-tailed prairie dog in Canada,<sup>5</sup> approved by the Minister of Environment in June 2009, were developed through the cooperation of federal government departments and agencies, the province of Saskatchewan, as well as representatives of major academic institutions and stakeholder groups such as the Toronto Zoo (captive breeding facility for the black-footed ferret), Calgary Zoo (Centre for Conservation Research) and a private landowner.

These conservation actions have been internationally coordinated through the Black-footed Ferret Recovery Implementation Team (BFFRIT), which is led by the United States Fish and Wildlife Service (USFWS). Since 1987, over 7000 kits have been born under management of the captive populations. Reintroduction of black-footed ferrets began in 1991, and since that time, over 2500 ferrets have been reintroduced at 19 locations in the USA (in eight of the 12 states within the historic range), Mexico and most recently to Canada (P. Marinari, pers. comm.; Fig. 2). Researchers have estimated that ferret numbers in the wild total 1000 during annual fall surveys, with approximately half surviving the winter to breed each spring.<sup>1</sup>

The return of black-footed ferrets to the Canadian prairies was celebrated on

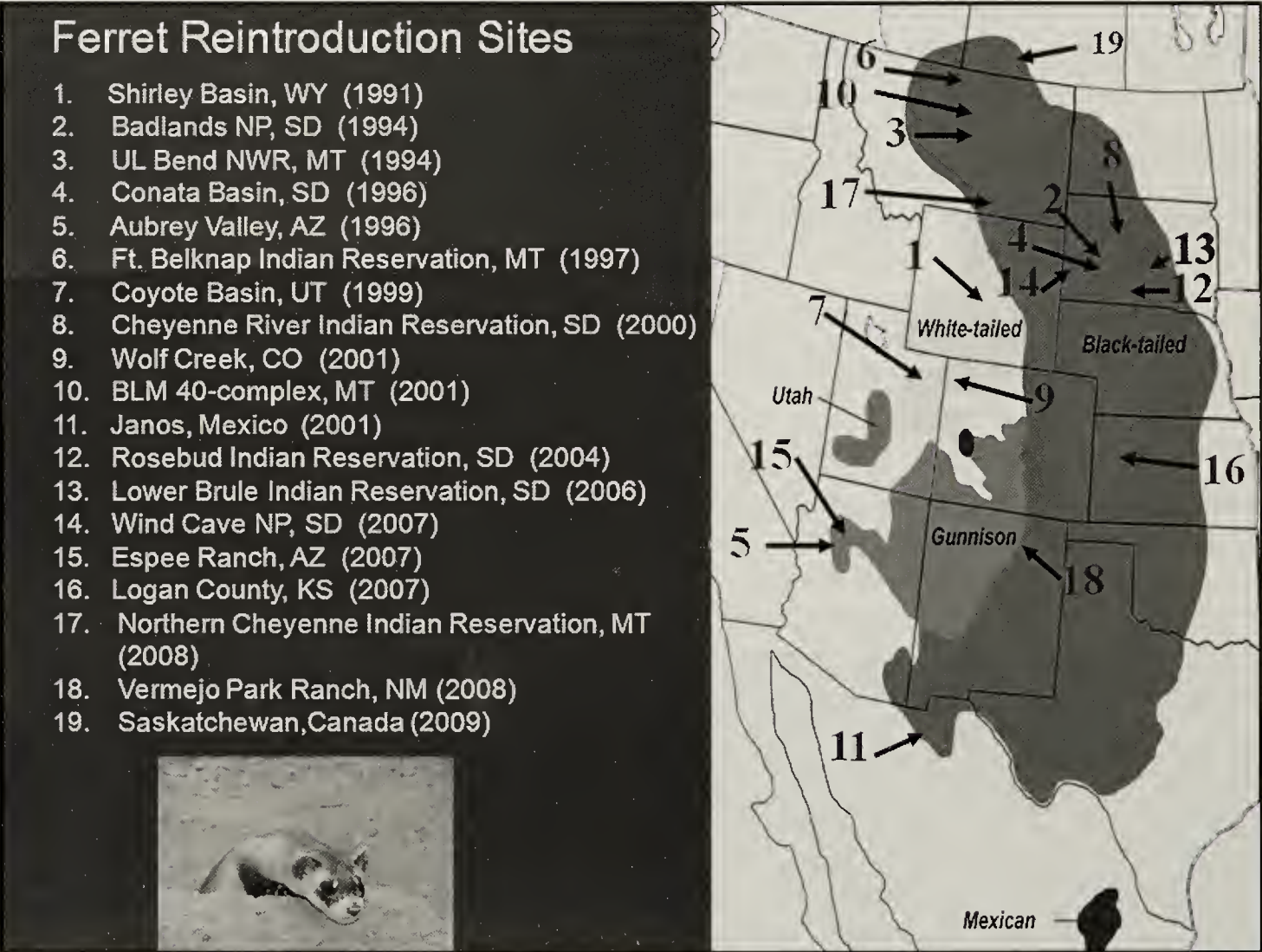


Figure 2. Black-footed ferret reintroduction sites across their historical range, which includes five species of prairie dogs: black-tailed, white-tailed, Utah, Gunnison and Mexican prairie dogs. US Fish and Wildlife Service, 2010





Figure 3. Black-footed ferret released into Grasslands National Park of Canada.  
 Johane Janelle, Parks Canada

2 October 2009, with the release of 34 ferrets into eight prairie dog colonies in the West Block of GNPC and on adjacent prairie dog colonies in privately managed lands (Fig. 3 and front cover photo). The journey home for these captive-born ferrets included spending a minimum of 30 days being pre-conditioned at the National Black-footed Ferret Conservation Centre in Ft. Collins, Colorado. Ferrets are typically 90 days old when placed into preconditioning pens with a natural burrow system and exposure to live prairie dogs. By 120–150 days of age, the ferrets are transported to their reintroduction sites.<sup>1</sup>

In 2010, for the first time in Canada, the reintroduced black-footed ferrets enjoyed a prairie springtime in their new grasslands home. Sixteen volunteers assisted Parks Canada staff during an intensive 10-day monitoring session in March 2010, by walking from 12 to 27 km per night while searching for ferrets in the prairie dog towns. Night spotlighting is the standard technique for tracking and monitoring of ferret populations.<sup>8</sup> Throughout the monitoring nights, participants used high-intensity spotlights to scan prairie

dog colonies in search of the distinct reflective emerald eye shine of the ferret. Upon positive observation, a specialized passive integrated transponder (PIT) tag scanner was used to individually identify each animal (Fig. 4).<sup>8</sup> The scanner's ring is placed around the burrow entrance containing the ferret, and the scanner "reads" the PIT tag (microchip) of the ferret when it moves through the sensitive ring, uniquely identifying the animal. Monitoring success depends on detecting ferret eyeshine when ferrets are active above ground during the night; time spent above ground will vary by individual, time since last feeding, and environmental conditions (moonlight, wind conditions). Detection and post-release success may be also influenced by the prevalence of predators like coyotes (*Canis latrans*) or great horned owls (*Bubo virginianus*).

Over 975 volunteer hours spent spotlighting in March 2010 resulted in the ferret trackers positively identifying 35% or 12 of the 34 ferrets originally released on 2 October 2009. The identified ferrets had a sex ratio of 4 males: 7 females, with one additional ferret sighting confirmed



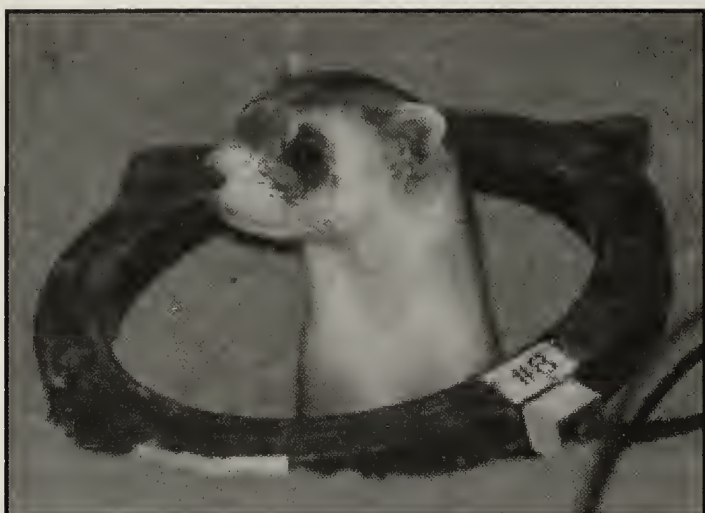


Figure 4. Black-footed ferret successfully PIT-tag scanned.

Paul Knaga, Parks Canada

but not PIT identified. The over-wintering survival of the captive-born ferrets is encouraging, as it is similar to the average annual survival rates of wildborn kits in Montana, which is 41% (R. Matchett, USFWS, unpublished data).

Parks Canada and its black-footed ferret recovery partners will continue to gain information on the reintroduced ferrets. Black-footed ferrets breed in March and April, and after a gestation period of 41 to 43 days, a female will usually have a litter of 3 to 4 kits.<sup>2</sup> Litter production will be assessed at the end of August 2010, and a second release of black-footed ferret kits is planned for late September 2010.

The monitoring and research planned following the initial ferret reintroduction will ensure maximum learning opportunities from this effort in order to advance prairie conservation and to share those lessons with the public. GNPC is looking forward to offering a unique opportunity for the public to volunteer in a 'Ferret Tracker' monitoring program in an effort to evaluate the recovery of this species and to continue to increase awareness of prairie conservation and black-footed ferrets. If you are interested in volunteering, contact GNPC at <grasslands.info@pc.gc.ca> or call 306-298-2257 for more information.

Today, it is estimated that 80% of Canada's mixed grasslands are gone. Returning North America's only native ferrets into this ecosystem is a small step towards ensuring robust diversity in this disappearing landscape. Recovery of an endangered species is a long-term commitment, wherein the longer that effort, the greater the likelihood of success. The future of black-footed ferrets in Canada is still uncertain, but the initial results are positive.

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## FISHWAY MONITORING AT THE CRAVEN DAM, QU'APPELLE RIVER, SASKATCHEWAN

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### Introduction

Fish migrate within and between water bodies seasonally to carry out various life processes such as feeding, avoiding predators, and reproducing.<sup>1</sup> Fish spawning migrations are extensive, sometimes involving dramatic changes in habitat use. Spawning fish often require habitats different from those where they spend much of their time as adults. For example, walleye (*Sander vitreus*) and northern pike (*Esox lucius*) may migrate within lakes, or from lakes into rivers, seasonal streams, and wetlands to seek suitable spawning habitat.<sup>2,3</sup> The initiation of spawning in fish is governed by day length, water temperature,<sup>2</sup> and to some extent, stream flows.

In Saskatchewan, there are many dams, weirs, and poorly designed road crossings constructed within seasonal creeks, streams, and rivers used for spawning by various fish species. These structures alter water flow regimes by constricting flow and creating velocity barriers that may partially impede or completely block fish from reaching habitats critical to fulfill their life processes, especially reproduction.<sup>1</sup> Barriers to fish passage can have negative impacts on fish populations if they block migration routes to and from spawning habitats,

especially for rare species and managed game fish populations. Accordingly, all new in-stream structures constructed in Saskatchewan where there are migratory fish species must be designed to appropriately facilitate fish passage as required by the federal *Fisheries Act*. However, it is also important to monitor the effectiveness of structures designed to accommodate fish passage and to ensure that they are functioning as intended.

The Qu'Appelle River system is one of the most important fish-bearing waterways in southern Saskatchewan, and has been subject to many human alterations and disturbances. In 2003, the water control structure in the Qu'Appelle River near the village of Craven was replaced. A fish bypass, or 'fishway,' was constructed in association with the structure to accommodate fish passage. The previous dam at Craven did not have a fishway. The focus of this study was to gain a better understanding of (1) how the new Craven Dam and associated fishway function, (2) the ability of the fish to migrate past the potential barrier, and (3) the behaviours of the fish when they encounter the fishway. This study was a cooperative project between the Saskatchewan Ministry of Environment



Figure 1. Qu'Appelle River system showing the location of the Craven Dam (circled in black). Map courtesy of the Saskatchewan Watershed Authority.

(MOE), the Department of Fisheries and Oceans (DFO), and the Saskatchewan Wildlife Federation (SWF).

### Study Area

The Qu'Appelle River is a major drainage system encompassing approximately 52,000 km<sup>2</sup> in southern Saskatchewan.<sup>4</sup> It originates at Lake Diefenbaker in the west and flows eastward to its confluence with the Assiniboine River near St. Lazare, Manitoba. The watershed contains seven major lakes and two reservoirs and supports a variety of fish species.<sup>5</sup> There are several water control structures on the Qu'Appelle River designed to manage water levels within the watershed, including the dam near Craven, which was the focus of this study.

The present structure of the Craven Dam (currently operated by the Saskatchewan Watershed Authority [SWA]) was built on the Qu'Appelle River just east of the Village of Craven within SW 24-20-21 W2M by Agriculture and Agri-Food Canada (Fig. 1). Construction started in August of 2002 and was operational by the spring of 2003 (C. Lazurko, pers. comm.). The main structure is 28.4 m wide (including the fishway) and is

comprised of four gated bays, each gate being 4.5 m wide and 2.15 m high.

An engineered vertical slot fishway was constructed on the north side of the structure adjacent to the river bank to facilitate fish passage around the dam. The fishway is 29.5 m long and 3.6 m wide. There are seven vertical baffles within the structure designed to reduce flow velocities and create refuges for migrating fish. At the upstream end of the fishway there is a gated bay. The gate measures 1.5 × 1.5 m and can be adjusted to regulate flows within the fishway. A steel fish trap can be lowered into the bay to sample fish that have successfully migrated through the fishway for scientific or monitoring purposes.

Manipulation of flows at the Craven Dam allows water managers to release water downstream to Pasqua Lake. It also allows water managers to constrict flow and backflood water into Last Mountain Lake via Last Mountain Creek to maintain lake levels or to use the lake as a reservoir for downstream flood protection. When the dam is open, water drains from Last Mountain Lake and the Qu'Appelle River watershed above the dam.



Methods

Fish Capture and Tagging

To assess fish passage, fish were first captured at the dam site. Fish were captured by two methods: the fish trap at the upstream end of the fishway and by gill nets set for short durations in the Qu'Appelle River on the downstream side of Craven Dam. The fish trap was typically set overnight for an 18- to 24-h period, approximately twice per week from April through June 2009 to capture fish that successfully migrated through the fishway. Trap sets became less frequent in July and August, averaging about one overnight set per week, as fish movement was expected to decrease after spawning was complete. Gill nets were set downstream of the dam for an average of about 2 h per day. Two gill nets were used: one with a 5 cm (2") stretched mesh and the other with a 7.5 cm (3") stretched mesh. Each net was 10 m long by 1.8 m deep. Gill nets were employed to increase the number of fish captured for tagging and to tag fish that may have congregated below the fishway and were unable to migrate past.

Passive Integrated Transponder (PIT) tags were used to assess fish movements through the fishway. These tags contain a microchip encased in glass and do not have an internal power source. A tag works by first using a scanner to send a low-frequency signal (via an antenna) to the microchip within the tag supplying the power needed to send its unique code back to the scanner, providing individual documentation for each fish. PIT tags were implanted into the abdominal cavity of fish. All tagged fish were released downstream of the dam. Prior to their release, the species, fork length, weight, and sex were recorded for each fish. Three antennae were installed at the vertical slot openings of the baffles in the fishway. The first antenna was installed at the baffle in the lower end of the fishway, the second antenna was installed approximately at the mid-point, and the third antenna was installed at the upper end of the fishway at the last baffle before the bay that contained the fish trap. By configuring the antennae in this manner, it could be determined when a fish entered the fishway, how far it moved through the fishway, and how long it remained in the

Table 1. Fish species (with four-letter abbreviation) captured by method.

Common name	Scientific name	Abbreviation	Number of fish captured	
			Trap	Gill Nets
Bigmouth buffalo	<i>Ictiobus cyprinellus</i>	BGBF	2	0
Common carp	<i>Cyprinus carpio</i>	CMCR	36	0
Lake whitefish	<i>Coregonus clupeaformis</i>	LKWH	1	0
Northern pike	<i>Esox lucius</i>	NRPK	1	53
Quillback	<i>Carpiodes cyprinus</i>	QUIL	2	0
Walleye	<i>Sander vitreus</i>	WALL	49	27
White sucker	<i>Catostomus commersonii</i>	WHSC	1807	44
Yellow perch	<i>Perca flavescens</i>	YLPR	2	0

Table 2. Fish trapped at the Craven Dam fishway. Abbreviations as in Table 1.

Number of fish trapped											
Date	Max. daily water temp (°C)	Turbidity (NTU)	NRPK	WALL	WHSC	CMCR	BGBF	LKWH	QUIL	YLPR	Total
16-Apr-09	2.46	-									0
22-Apr-09	8.23	-									0
30-Apr-09	6.62	-									0
6-May-09	12.16	-			97						97
7-May-09	11.77	-			97						97
12-May-09	14.47	85		2	230						232
13-May-09	14.09	75		2	222						224
14-May-09	11.77	-		5	91						96
20-May-09	10.99	60		3	100						103
26-May-09	17.14	62		3	300	3	1		1		308
27-May-09	17.90	68	1	6	397	5	1				410
28-May-09	19.42	73			91	2					93
2-Jun-09	18.66	67			99	1		1	1		102
9-Jun-09	12.16	65		5	14						19
10-Jun-09	14.85	62		3	16						19
30-Jun-09	23.24	145		3	3	7					13
8-Jul-09	19.42	135		1	14	9					24
14-Jul-09	20.95	110		2	2						4
21-Jul-09	21.33	70			11	7					18
28-Jul-09	22.48	48		6	3	1					10
5-Aug-09	19.42	50		3	4						7
11-Aug-09	22.09	52		3	1	1					5
18-Aug-09	18.28	55		2	15					2	19
Total			1	49	1807	36	2	1	2	2	1900



Table 3. Number, sex, and size structure of tagged fish. F: female, M: male, U: unknown. Species abbreviations as in Table 1.

			Fork Length (mm)		Weight (g)	
Species	Sex	n	Range	Mean	Range	Mean
WHSC	F	5	370 - 450	412	700 - 1750	1072
	M	5	310 - 410	364	500 - 1100	790
	U	1	448	-	1400	-
WALL	F	22	545 - 740	622	1700 - 4700	2895
	M	5	565 - 730	638	2100 - 3900	2870
	U	31	348 - 745	554	500 - 4400	2050
NRPK	F	11	530 - 970	686	1200 - 6350	2527
	M	12	390 - 670	531	550 - 1900	1208
	U	25	474 - 850	576	900 - 4000	1498
LKWH	U	1	540	-	2800	-
BGBF	U	1	610	-	6000	-
QUIL	U	1	400	-	1200	-

fishway. Data recorded by the scanner were logged on site.

Water Flow and Quality

Flow data for the Qu’Appelle River were obtained from the Water Survey of Canada and SWA for the hydrometric station near Lumsden (05JF001) and the station below the Craven Dam (05JK002). Water temperature and turbidity were monitored throughout the study period. Water temperature was recorded in degrees Celsius using a temperature logger installed in the fishway. Readings were logged every hour from 16 April to 28 August 2009. Turbidity measurements were recorded weekly beginning 12 May 2009, using a visual clarity wedge and approximated in nephelometric turbidity units (NTUs, a proxy for clarity).

Results

Fish Capture and Tagging

Eight fish species were captured in the fish trap, and three species in gill nets (Table 1). In total, 1900 fish were captured in the trap on 23 sampling events between

16 April and 18 August 2009 (Table 2). An additional 124 fish were captured in gill nets downstream of the dam. Of the captured fish, 120 were marked with PIT tags. Walleye, northern pike, white sucker, lake whitefish, bigmouth buffalo, and quillback were PIT tagged. Table 3 shows the sex and size classes of each species tagged.

Water Flow and Quality

Water flows and temperature were expected to be the most significant triggers for fish movements in the Qu’Appelle River system, particularly at the Craven Dam. Figure 2 depicts the flow at the hydrometric stations at Lumsden (upstream of the dam) and below the Craven Dam. Flows rapidly increased at Lumsden starting on 1 April and peaked on 21 April 2009. The majority of the water was stored in Last Mountain Lake until 5 May, when releases were increased to 13 m³/s below the Craven Dam.

The greatest numbers of fish were captured at the dam during the spring spawning season, primarily in May.

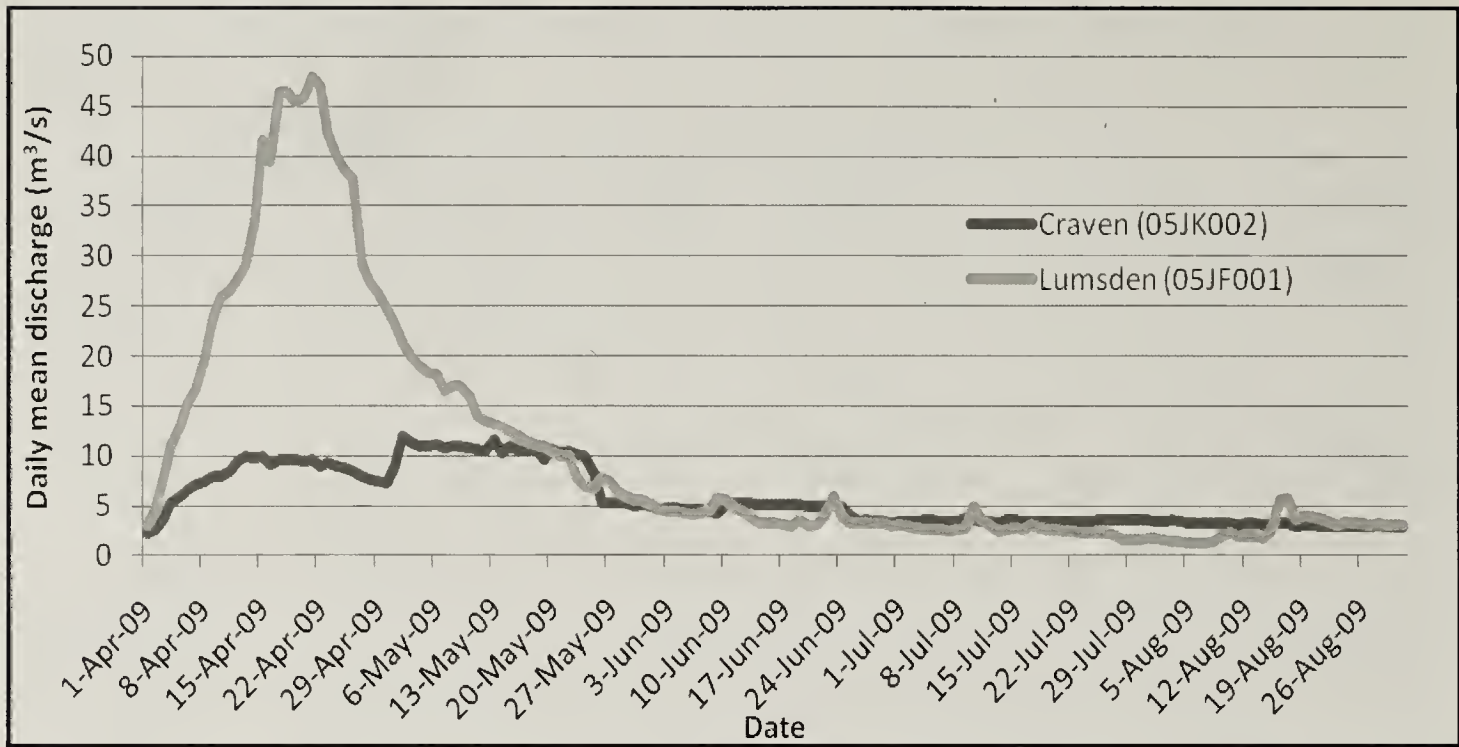


Figure 2. Qu'Appelle River daily mean discharge (m³/sec) at Lumsden and below the Craven Dam, 1 April to 31 August 2009.

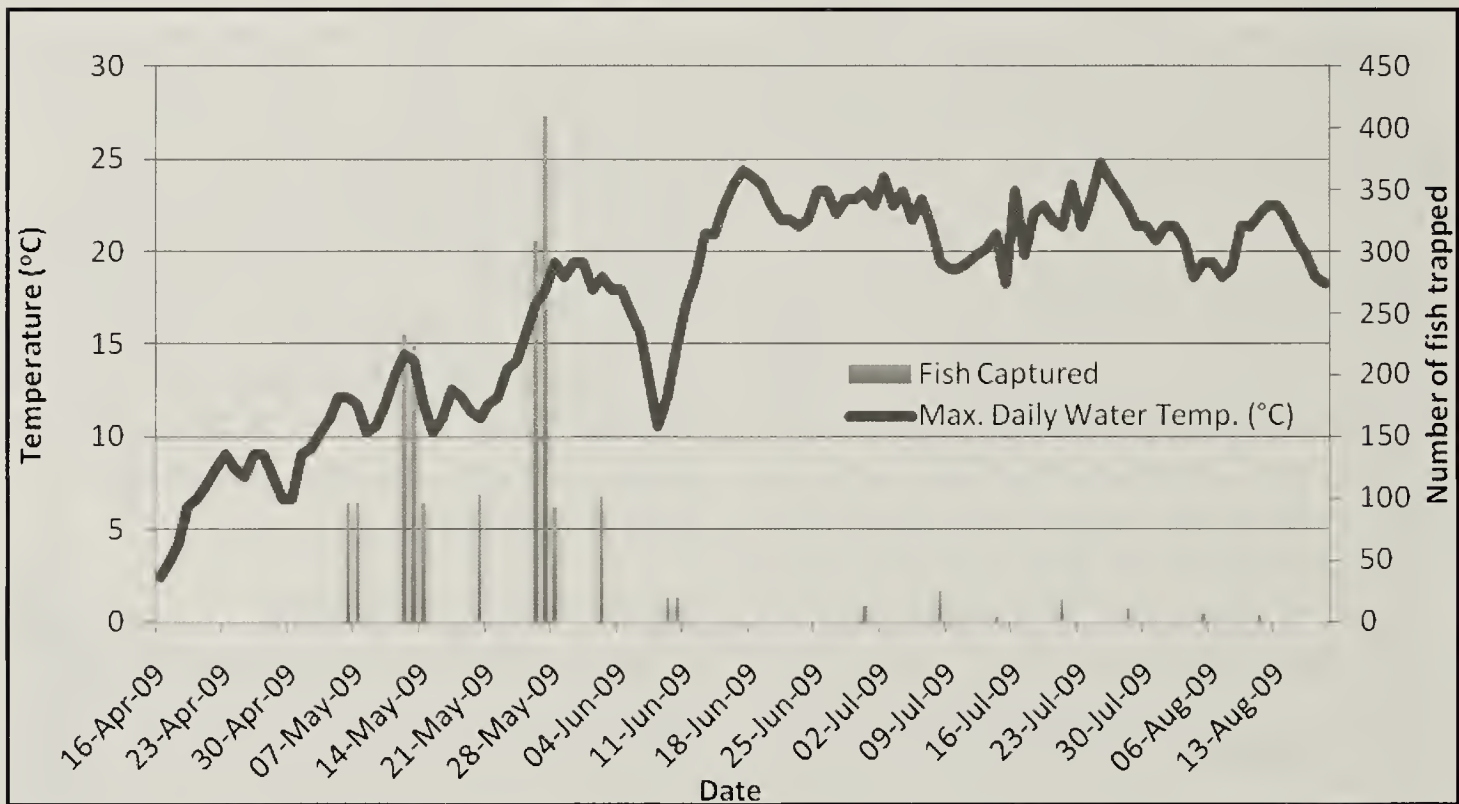


Figure 3. Maximum daily surface water temperatures (°C) and number of fish trapped at the Craven Dam, 16 April to 18 August 2009.

Capture rates in the fishway trap increased with water temperature and flow below the Craven Dam throughout May, but subsided by early June and remained lower for the rest of the summer. No fish were captured in the fish trap during the first three sampling events (16, 22, and 30 April 2009), and the first fish was caught in the trap on 6 May. Figure 3 relates the number of fish captured in the trap during

the sampling period with the daily water temperatures. There was an increase in fish capture rates and water temperature during May and early June. High capture rates in May also correspond to the greatest discharge below the Craven Dam.

Fish movements through the fishway varied with respect to time of day. Twenty-





Figure 4. Bigmouth buffalo (*Ictiobus cyprinellus*; left) and quillback (*Carpiodes cyprinus*; right).

six PIT-tagged fish successfully migrated through the fishway during the study period: 15 walleye, four white sucker, six northern pike, and one quillback (see Fig. 4, which shows bigmouth buffalo and quillback, two of the rarer species captured). The majority of these fish (63%) moved during the evening hours (Fig. 5). Another 43 tagged fish were detected in the fishway by the antennae; however, these fish did not pass through the full length of the fishway.

### Discussion

The results of this study indicate that the Craven Dam fishway was used by various fish species during the spring and summer conditions experienced in 2009. The results can likely be extrapolated to similar flow years, but not necessarily under all conditions. Field staff observed fish in the lower end of the fishway during April, yet no fish were captured in the trap during that time. The first fish caught in the trap that successfully migrated

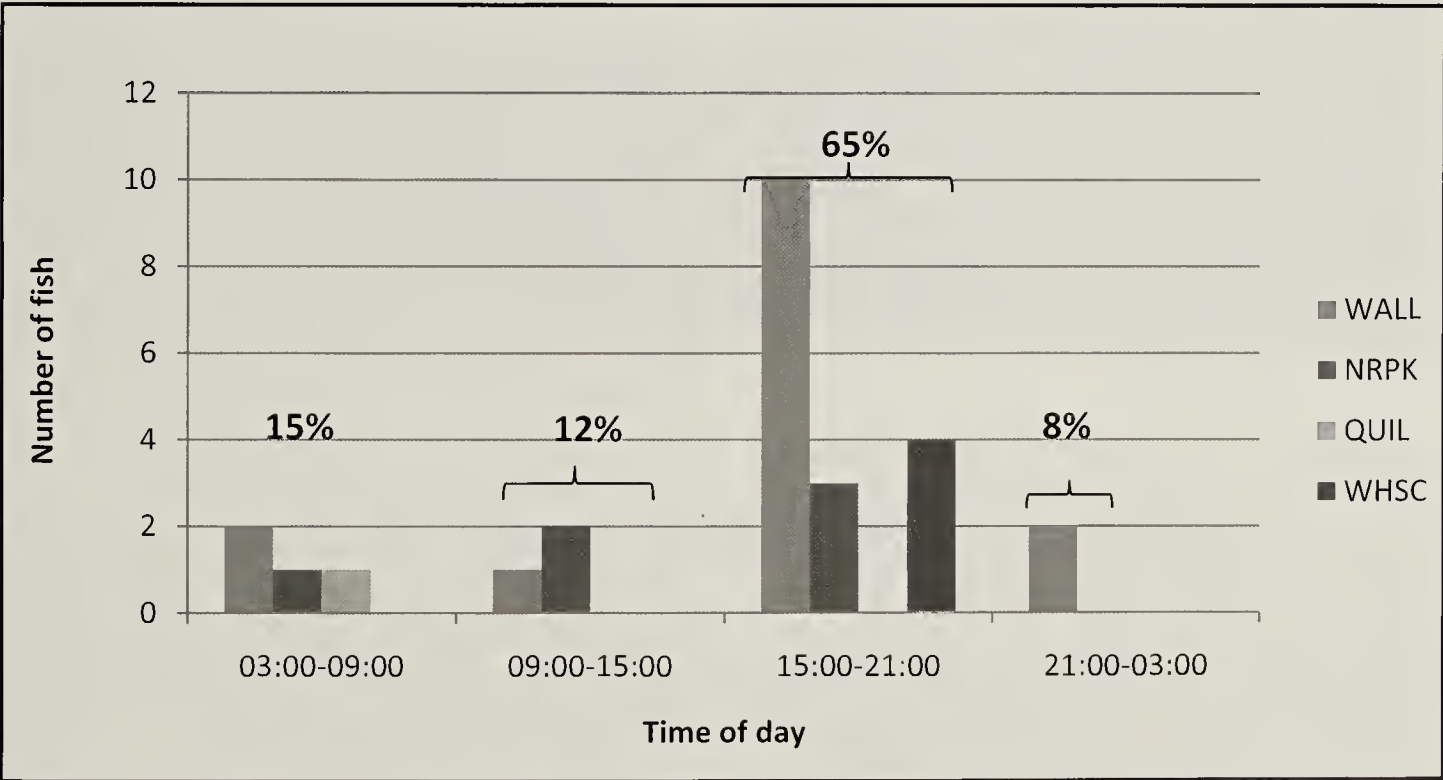


Figure 5. Time of day tagged fish successfully migrated through the fishway at the Craven Dam. Note that the percent value written above each group indicates the percentage of total fish that successfully migrated through the fishway during that time period. Abbreviations as in Table 1.

through the fishway occurred on 6 May, and the first successful migration by a PIT-tagged fish occurred on 11 May. This could correspond to an increased discharge below the Craven Dam (greater water release below the dam raises the tail water level below the dam) and an increase in water temperature (Figs. 2 and 3). On 5 May, SWA set the main gates at the dam to achieve a downstream release of approximately 13 m<sup>3</sup>/s from approximately 7 m<sup>3</sup>/s. Higher flows may have triggered upstream migration for fish downstream of the dam. Rising water temperatures could also have triggered fish migrations, especially for walleye and white sucker. Northern pike are reported to begin spawning when water temperatures are around 4°C, whereas walleye begin at 6°C, and white sucker around 10°C.<sup>3</sup> Water temperatures in April were more favourable for northern pike migration; however, flow velocities within the fishway may have been too high for pike to overcome, explaining why they were not captured in the trap (but many below it in gill nets). By the time flows in the fishway were lower, spawning conditions for northern pike had possibly diminished. Lower flow velocities in the fishway coupled with water temperatures in May that were more favourable for walleye and white sucker migration could explain the higher numbers of walleye and white sucker captured in the trap at that time.

Fish moved through the fishway at all times during the day and night. However, when considering only the fish that successfully migrated past the dam, there was a much greater tendency for fish to move during the evening hours (15:00 to 21:00 h), especially walleye (Fig. 5). Forty-three (36%) PIT-tagged fish were detected in the fishway, but did not migrate all the way through. Fifty-one percent of these fish were detected on more than one occasion. Most of the

detections occurred in June to August, after the spawning season. In conjunction with field observations, these results suggest that these fish were likely moving in and out of the fishway to forage and were not necessarily attempting to move past the dam and migrate to upstream habitats.

Based on the results of this study, it can be concluded that various species of fish use the fishway at the Craven Dam throughout the open water season, but temporary restrictions to upstream fish passage may occur during certain flow conditions and critical life history stages (i.e., spawning periods). Information gathered in this study may be used by fisheries managers and fish habitat biologists to determine how to sustainably manage local fisheries and impacts from development and water management regimes within the Qu'Appelle River system.

Future monitoring is recommended to investigate flow velocities within the fishway during the spring freshet. It is also recommended that a fish movement study be conducted within the Qu'Appelle River watershed to obtain a better understanding of the origin of fish migrating upstream and downstream in the Qu'Appelle River system, and the importance of migrations to the fishery. Further, a water management operating plan should be developed in consultation with DFO, MOE, SWA, and other relevant stakeholders. The plan should be active and adaptive to ensure that water management activities have minimal impacts on upstream fish migrations in the Qu'Appelle River during the spring spawning period.

### **Acknowledgements**

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Prairie falcon (*Falco mexicanus*).

Randy McCulloch



*Climb the mountains and get their good tidings.  
Nature's peace will flow into you as sunshine flows into trees.  
The winds will blow their own freshness into you...  
while cares will drop off like autumn leaves.*

- John Muir

## TAXONOMY OF WILD ONIONS (*ALLIUM*) IN SASKATCHEWAN

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Onions (*Allium species*) rank second in economic value after tomatoes in the list of cultivated vegetable crops worldwide.<sup>1</sup> For generations, humans have consumed over 20 *Allium* species other than the cultivated garden onion (*A. cepa* L.).<sup>2</sup> Both Old and New World *Allium* members are becoming popular worldwide, including edible and culinary species, e.g., Chinese chives (*A. tuberosum* Rottl. ex Spreng.) and attractive ornamental plants, such as nodding onion (*A. cernuum*) and giant onion (*A. giganteum* Regel). Similarly, consumers and researchers alike are more aware of the health benefits and medical properties of alliums.<sup>3</sup> Despite the cultural, economic, nutritional, and health significance of *Allium* in human society, to date, its taxonomy remains complex due to the proliferation of synonyms and disagreement regarding taxonomic characters used in species boundaries. In fact, the complex taxonomic history of *Allium* involves 1400 specific epithets, some of which have been synonymised,<sup>4</sup> but no comprehensive generic monograph has been compiled since that of Regel (1875).<sup>5</sup>

*Allium* is widely distributed only in the Northern hemisphere, especially in the temperate regions of Eurasia.<sup>6–8</sup> The genus includes over 800 species, and

according to Raven and Axelrod (1978), *Allium* has been present in the New World since at least the Tertiary Period.<sup>9</sup> Approximately 1/6 of the world's *Allium* diversity is represented in North America north of Mexico, that is, about 96 species, of which 12 are known from Canada.<sup>10,11</sup>

Several criteria have been used in *Allium* classification. Among these, sexuality of flowers, structure and shape of the underground parts (including rhizome and bulb), anatomical features of root, leaf, scape, and ovary, as well as basic chromosome number have been valuable at the subgeneric and sectional levels.<sup>7,10,12–15</sup> In turn, shape and size of floral organs, such as perianth, filament, pistil, capsule, and seed in addition to somatic chromosome number have taxonomic significance at the specific level.<sup>10,16,17</sup>

In the past, the Canadian prairie landscape of the provinces of Alberta, Saskatchewan (SK), and Manitoba encompassed extensive grasslands, aspen parklands, and abundant wetland areas, all supporting a rich diversity of native biota.<sup>18</sup> However, in the last decades, large prairie areas have been cleared and converted to cropland. Lamentably, the prairies now form the



largest expansion of agricultural land in Canada and represent one of the most human-altered and fragmented landscapes in the country.<sup>18–20</sup> In addition to hosting unique prairie ecosystem biodiversity, the province of SK reportedly has numerous native plants, including five *Allium* species, namely *A. schoenoprasum* var. *sibiricum*, *A. geyeri* var. *geyeri*, *A. textile*, *A. cernuum*, and *A. stellatum*.<sup>11,21</sup> Among these, *A. geyeri* var. *geyeri* is included in SK's rare and endangered plant list, in addition to *A. cernuum* and *A. schoenoprasum*.<sup>21,22</sup>

Although Harms (2003) provided an assessment regarding rarity status of species in SK,<sup>21</sup> a formal taxonomic scheme including typification, nomenclatural history, and synonyms is lacking. It should be mentioned, however, that Scoggan (1978), Boivin (1979), and Budd (1987) treated all *Allium* species in SK, although not with the thoroughness of a detailed taxonomic monograph.<sup>23–25</sup> Here, we present a taxonomic treatment of *Allium* in the province based on the combination of quantitative and qualitative data from vegetative and reproductive characters. The goals of this study were to expand the current knowledge of the morphology and distribution and to provide a taxonomic key for the species. This study provides sound foundations for updating provincial taxonomic treatments of *Allium* and the family Liliaceae.

## Materials and Methods

This study is based on specimens of collections from the following herbaria: ALTA, DAO, LINN, MO, NY, SASK, and WIN. All species were also field-collected by the authors in 2009. Morphological characters from vegetative (rhizome, bulb, leaf, and scape) and reproductive (perianth, stamen, pistil, fruit, and seed) structures were measured in a minimum of 30 and 20 specimens, respectively. Parts from the middle third of the second

leaf blade and a scape of a floriferous culm were used for observation of cross-sections. Leaf and scape tissues, fixed in 70% ethanol, were hand-sectioned, stained with safranin, washed with distilled water, observed, and photographed using a TESSOVAR Photomacrographic Zoom System with a Nikon D100.

A map depicting the distributional range was prepared for each species (Fig. 1) based on herbarium specimens. The maps were generated using a customized map development tool especially designed and based on the open-source code Google™ Maps API on-line development tool. The mapping software and data used can be found at the W. P. Fraser Herbarium (SASK) website (<http://herbarium.usask.ca>). A data table of *Allium* locations for SK was generated. When latitude and longitude were not provided on the voucher specimens, the coordinates were calculated based on the locality information using the Natural Resources Canada on-line Atlas of Canada reference maps (<http://atlas.nrcan.gc.ca/site/english/maps/topo/map>). Once the data table was linked to the mapping program, the maps were plotted. The Google™ map initially presented through the mapping program had the geographic boundaries of Canada. Afterwards, it was imported into Adobe Photoshop 7.01 as a JPEG graphic, and the boundaries were removed so that only SK remained.

## Results and Discussion

The following taxonomic treatment is based on a wide array of morphological characters. Characters indicated within square brackets ([ ]) are absent in the species of SK but are used in the description of *Allium* in floras and monographs throughout the world.

*Allium* L., Sp. Pl. 1: 294 (1753).  
Description: Herbs perennial, bulbiferous.

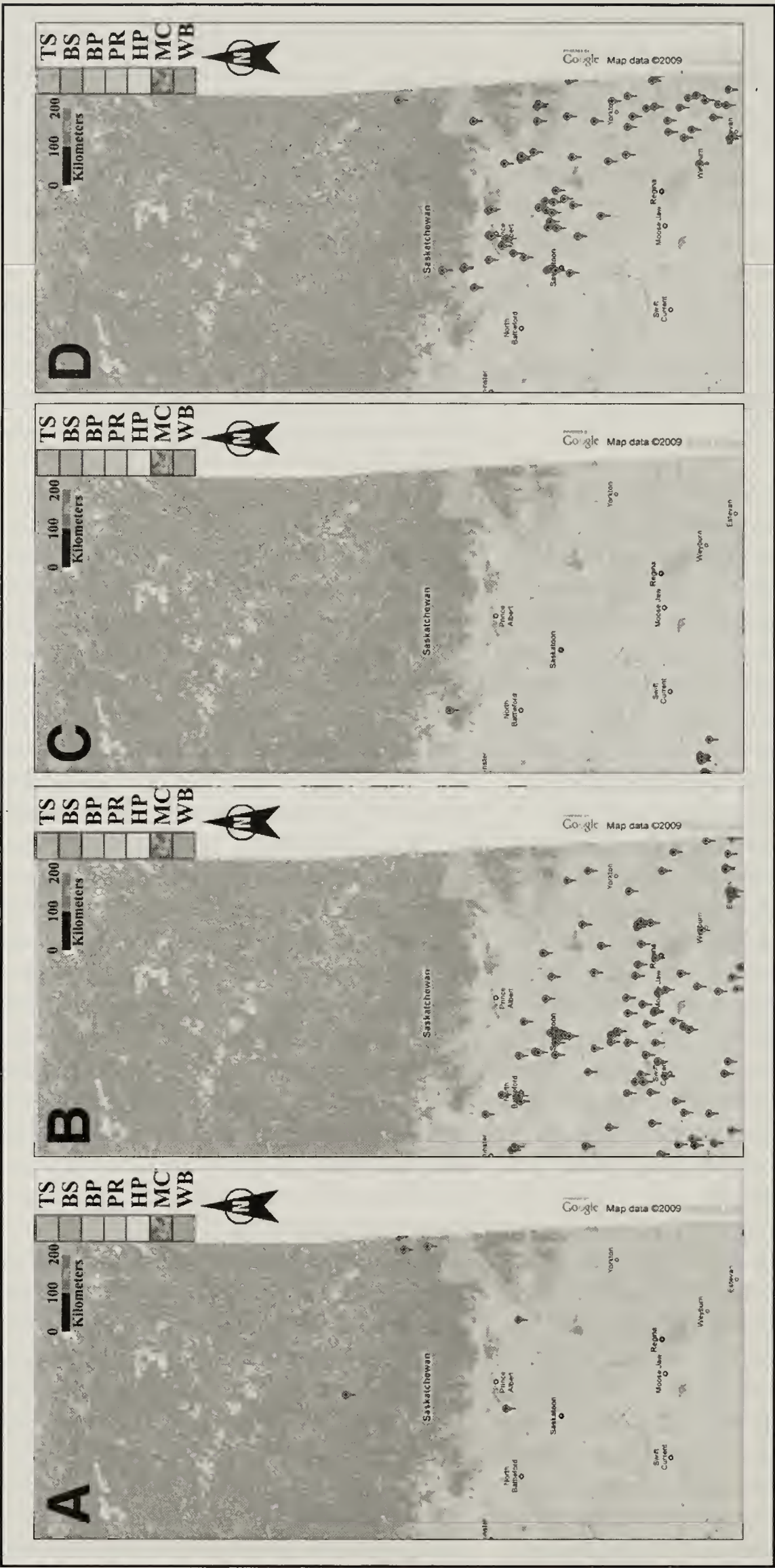


Figure 1. Geographic distribution of *Allium* species in Saskatchewan (WB: Water body; MC: Mountain Cordillera; HP: Hudson Plain; PR: Prairie; BP: Boreal Plain; BS: Boreal Shield; TS: Taiga Shield). A) *A. textile*; B) *A. schoenoprasum*; C) *A. cernuum*; D) *A. stellatum*.



Rhizomes condensed [or elongated], sometimes obsolete (not rhizomatous), erect to horizontal. Bulbs tunicate, solitary to clustered, [sometimes with basal bulbils], cylindrical to globose; tunicas membranous, papery, or fibrous, smooth to reticulate. Leaves alternate; leaf sheaths [buried] or exposed over ground; leaf blades linear [or rarely elliptical to oval], flat, angular, or terete, with 1 or 2 rows of vascular bundles, and solid or hollow in cross-section, sessile, attenuate, [or rarely narrowed into pseudo-petiole at base], acuminate [to rounded] in apex. Scapes usually central from bulbs, [slender or] stiff, erect to recurved at the upper parts, terete, angular, [or flattened-winged], with 1- to 3-circular vascular bundles, and solid or hollow in cross-section. Inflorescences terminal, usually an umbel, [sometimes replaced totally or partially by bulbils], wholly enclosed by a scarious spathe-like bract before flowering; umbels fascicled to globose; pedicels terete [or rarely angular], thinner [or rarely thicker] than the scapes, equal [to distinctly unequal] in length. Flowers bisexual [or rarely unisexual], regular, actinomorphic; perianth campanulate to stellately spreading, with greenish or reddish mid-vein abaxially; tepals 6, in 2 series, usually unequal, connate at base, persistent after flowering; inner ones oblong to ovate, acute to obtuse at apex; outer ones oblong to orbicular, acute to subrounded at apex; stamens 6; filaments adnate to the lower part of tepals, exserted or not, connate and usually dilated at base, entire [or toothed at margin]; anthers 2-locular, longitudinally dehiscent, usually elliptical, yellowish [or reddish]; ovary superior, greenish, [reddish, or brownish], trigonous [or not], sometimes with crest-like (apical) or hood-like (basal) appendages, locules 3, ovules usually 2 per locule, placenta axile; style 1, erect, filiform, exserted or not; stigma conically smooth, [capitate, or rarely trifid]. Fruits capsules, dehiscent, [subglobose],

ellipsoid, or cordiform, trigonous [or not]. Seeds black, elliptical to circular, flat to circular in cross-section.

In this study, we recognize four *Allium* species for SK, namely: *A. cernuum*, *A. schoenoprasum*, *A. stellatum*, and *A. textile*, which are the same recognized by McNeal and Jacobsen (2002) and Harms (2003),<sup>11,21</sup> except that our study excludes *A. geyeri*. The existing herbarium specimens of *A. geyeri* var. *geyeri* in SK<sup>11,21</sup> are misidentifications and correspond to *A. textile*.<sup>26</sup> Therefore, and even though *A. geyeri* is listed as endangered (END)<sup>21</sup> and S1 (five or fewer occurrences and particularly vulnerable to extinction) in SK,<sup>22</sup> this species should be excluded from the rare list as well as from the provincial flora.

**Key to the *Allium* species of Saskatchewan**

1. Leaf blades terete, hollow in cross-section; scapes hollow in cross-section; tepals 10.0–15.0 mm long; ovary ellipsoid, with hood-like appendages at base; capsules ellipsoid; seeds elliptical, angular in cross-section -----

----- **1. *A. schoenoprasum***  
(Fig. 2, see inside front cover)

1. Leaf blades flat, channelled, semiterete, or V-shaped, solid in cross-section; scapes solid in cross-section; tepals 3.8–8.8 mm long; ovary subglobose, without appendages or with crest-like appendage at apex; capsules cordiform; seeds oval to broadly oval, semiterete in cross-section.

2. Rhizomes obsolete, erect, 0.5–2.7 mm long; tunicas of bulbs fibrous, reticulate; leaves 2–4 (usually 2); outer filaments non-exserted; ovary without appendage at apex; styles non-exserted; seeds broadly oval; flowering from April to July -----**2. *A. textile***  
(Fig. 3, see inside front cover)

2. Rhizomes condensed, oblique, 2.0–7.7 mm long; tunicas of bulbs membranous, smooth; leaves 3–7; outer filaments exserted; ovary with crest-like appendage at apex; styles exserted; seeds oval; flowering from June to September.

3. Leaf blades nearly flat in cross-section; scapes recurved at the upper parts before and after anthesis; perianth campanulate (tepals erect), pink to white, with greenish midveins, inner tepals ovate, 5.0–6.7 mm long, 3.0–4.3 mm wide; outer tepals oval to orbicular, subrounded at apex, 3.8–4.8 mm long, 3.1–4.2 mm wide; inner filaments exserted -----

-----**3. *A. cernuum***  
(Fig. 4, see inside front cover)

3. Leaf blades nearly channelled to V-shaped in cross-section; scapes recurved at the upper parts before anthesis and becoming erect during flowering; perianth stellate (tepals spreading), deep pink, with reddish midveins, inner tepals elliptical-lanceolate, 7.2–7.7 mm long, 2.3–3.5 mm wide; outer tepals elliptical, acute at apex, 6.0–6.2 mm long, 2.8–3.0 mm wide; inner filaments non-exserted -----**4. *A. stellatum***  
(Fig. 5, see inside front cover)

1. *Allium schoenoprasum* L., Sp. Pl. 1: 301 (1753). Fig. 2 (see inside front cover)

= *A. sibiricum* L., Mant. Pl. Altera: 562 (1771).

= *A. schoenoprasum* L. var. *lautentianum* Fernald, Rhodora 28: 167 (1926).

We do not consider *A. schoenoprasum* L. var. *sibiricum* (L.) Hartm. treated in the SK flora by Harms (2003)<sup>21</sup> as a valid name because it is not included in the International Plant Names Index database and the original publication

cannot be found.

Description: Rhizomes condensed, distinctly oblique, 5.0–10.0 mm long. Bulbs cylindrically conical, 7.0–15.0 mm in diam.; tunicas papery, smooth, dark brown. Leaves 1 or 2; leaf sheaths 7.0–20.0 cm high; leaf blades terete, hollow in cross-section, acuminate at apex, 15.0–40.0 cm long, 2.0–9.0 mm wide. Scapes erect before and after flowering, terete, hollow in cross-section, 12.0–50.0 cm long, 2.0–8.0 mm wide. Umbels subglobose, 20.0–35.0 mm high, 25.0–40.0 mm wide, without bulblets, 16–80 flowered; pedicels 5.0–10.0 mm long; bracts 11.0–20.0 mm long. Perianth campanulate, reddish pink, with reddish midveins, inner tepals nearly equal to outer ones, oblong-lanceolate, acute at apex, 11.0–15.0 mm long, 2.5–3.5 mm wide; outer tepals oblong-lanceolate, acute at apex, 10.0–15.0 mm long, 2.7–3.5 mm wide; filaments non-exserted, 3.7–7.0 mm long; anthers 1.3–1.5 mm long; ovary ellipsoid, with hood-like appendages at base, 2.3–2.8 mm long, 1.8–2.4 mm wide; style non-exserted. Capsules ellipsoid, 4.1–4.3 mm long, 3.2–3.5 mm wide. Seeds elliptical, angular in cross-section, 3.3–3.6 mm long, 1.5–1.8 mm wide.

Phenology: Flowering from June to August.

Distribution: Europe, Asia, and North America.

SK: Boreal areas, taiga shields, and lake shores of central and northern provincial areas (Fig. 1A).

Remarks: According to Choi and Cota-Sánchez (in press), this species is easily distinguished from the other *Allium* species in SK by the ovary with basal hood-like appendages and the hollow leaves and scapes.<sup>26</sup>

2. *Allium textile* A. Nelson & J.F. Macbride, Bot. Gaz. 56: 470 (1913). Fig. 3 (see inside front cover)

≡ *A. geyeri* S. Watson var. *textile* (A.



Nelson & J.F. Macbride) B. Boivin, *Naturaliste Canad.* 94: 521 (1967).  
= *A. aridum* Rydb., *Fl. Rocky Mts.* 159: 1061 (1917).

Description: Rhizomes nearly obsolete, erect, 0.5–2.3 mm long. Bulbs ovoid, 7.0–25.0 mm in diam.; tunicas fibrous, reticulate, gray to light brown. Leaves 2–4; leaf sheaths 3.5–10.0 cm high; leaf blades adaxially channelled to semiterete, solid in cross-section, acuminate to acute at apex, 8.0–20.0 cm long, 1.0–3.0 mm wide. Scapes curved before anthesis and becoming erect in flowering, terete, solid in cross-section, 10.0–37.0 cm long, 0.8–3.0 mm wide. Umbels subfascicled to hemispheric, 12.0–42.0 mm high, 18.0–55.0 mm wide, without bulblets, 7–41 flowered; pedicels 4.0–20.0 mm long; bracts 7.5–16.0 mm long. Perianth campanulate to urceolate, white, with reddish midveins, inner tepals narrower than outer ones, oblong, obtuse at apex, 4.5–8.8 mm long, 2.0–2.8 mm wide; outer tepals broadly ovate to lanceolate, acute to obtuse at apex, 4.0–7.8 mm long, 2.5–3.9 mm wide; filaments non-exserted, 2.7–5.3 mm long; anthers 0.9–1.5 mm long; ovary subglobose, without appendages, 1.3–2.0 mm long, 1.4–1.9 mm wide; style non-exserted. Capsules cordiform, 3.5–4.6 mm long, 3.6–5.2 mm wide. Seeds broadly oval, semicircular in cross-section, 2.5–3.0 mm long, 1.8–2.1 mm wide.

Phenology: Flowering from April to July.

Distribution: North America.

SK: Dry grasslands, hills, and riversides of central to southern parts of the province (Fig. 1B).

Remarks: *Allium textile* is the most widespread species of the genus in SK (Fig. 1B) and exhibits extreme variability in plant length, leaf number, and floral size.<sup>26</sup> Although most plants have two leaves, some specimens have three or four. Our field observations indicate that individuals with three or four leaves tend

to develop a longer perianth than those individuals with two leaves. Specimens of *A. textile* with more than three leaves have been misidentified as *A. geyeri* var. *geyeri* in various Canadian herbaria, but the former is easily distinguished by its white perianth (as opposed to pink in *A. geyeri*; see Fig. 3, inside front cover) and nearly absent crest-like appendage in the ovary (as opposed to distinct appendage in *A. geyeri*) as well as longer pedicel and shorter scape.<sup>26</sup> Similarly, the type specimen of *A. geyeri* var. *geyeri* from the Rocky Mountains filed at NY shows several differences from the SK specimens labeled “*A. geyeri* var. *geyeri*”, especially in inflorescence size and perianth colour. In addition, *A. textile* is clearly distinguished by granulate seed testa periclinal cell walls from *A. geyeri* var. *geyeri*, which have verrucate walls.<sup>26</sup>

3. *Allium cernuum* Roth, *Arch. Bot.* (Leipzig) 1: 40 (1798). Fig. 4 (see inside front cover)

= *A. allegheniense* Small, *Bull. New York Bot. Gard.* 1: 279–280 (1899).

= *A. recurvatum* Rydb., *Mem. New York Bot. Gard.* 1: 94 (1900).

Description: Rhizomes condensed, oblique, 2.0–7.7 mm long. Bulbs ovoid, 8.3–22.0 mm in diam.; tunicas membranous, smooth, gray to brown. Leaves 3–7; leaf sheaths 3.0–10.0 cm high; leaf blades nearly flat, solid in cross-section, acuminate to obtuse at apex, 5.0–27.5 cm long, 1.2–8.0 mm wide. Scapes recurved at the upper parts before and after anthesis, terete to angular, solid in cross-section, 13.5–48.0 cm long, 1.1–4.0 mm wide. Umbels hemispheric to globose, 17.0–42.0 mm high, 21.0–46.3 mm wide, without bulblets, 12–42 flowered; pedicels 6.0–20.0 mm long; bracts 9.0–13.5 mm long. Perianth campanulate, pink to white, with greenish midveins, inner tepals unequal to outer ones, ovate, acute at apex, 5.0–6.0 mm long, 3.0–4.3 mm wide; outer tepals oval

to orbicular, subrounded at apex, 3.8–4.8 mm long, 3.1–4.2 mm wide; filaments exerted, 3.5–9.0 mm long; anthers 1.8–2.0 mm long; ovary subglobose, with crest-like appendages at apex, 2.2–3.0 mm long, 2.4–3.0 mm wide; style exerted. Capsules cordiform, 3.8–6.5 mm long, 4.3–6.5 mm wide. Seeds oval, semicircular in cross-section, 2.5–3.8 mm long, 2.0–2.4 mm wide.

Phenology: Flowering from June to August.

Distribution: North America.

SK: Dry hills and arid slopes in central-western and south-western regions (Fig. 1C).

Remarks: Taxonomically, *A. cernuum* is closely related to *A. stellatum*.<sup>11</sup> The character most commonly used to differentiate these two species is the orientation of the umbel-shaped inflorescence. In both species, the inflorescence may often be nodding (recurved) in the budding stage, but in *A. stellatum*, the inflorescence usually becomes erect during anthesis (Fig. 5, see inside front cover). In *A. cernuum*, the scape remains permanently curved near the apex (Fig. 4, see inside front cover), but sometimes the inflorescence may become erect or nearly so.<sup>11</sup> In addition, the perianth shape in *A. cernuum* is campanulate with ascending tepals (Fig. 4, see inside front cover), while in *A. stellatum* it is stellate with apically spreading tepals (Fig. 5, see inside front cover). Also *A. cernuum* differs from *A. stellatum* in having verrucate periclinal cell walls of seed testa.<sup>26</sup>

4. *Allium stellatum* Ker Gawler, Bot. Mag. 38: 1576 (1813). Fig. 5 (see inside front cover)

Description: Rhizomes condensed, oblique, 2.0–7.0 mm long. Bulbs ovoid, 8.0–17.7 mm in diam.; tunicas membranous, smooth, gray to brown. Leaves 3–7; leaf sheaths 5.0–11.0 cm high; leaf blades channelled to V-shaped,

solid in cross-section, acuminate to acute at apex, 15.0–36.0 cm long, 1.0–3.6 mm wide. Scapes usually recurved at the upper parts before anthesis and becoming erect in flowering, terete to dully angular, solid in cross-section, 25.0–62.0 cm long, 1.3–2.8 mm wide. Umbels subfascicled to hemispheric, 16.0–34.0 mm high, 24.0–48.2 mm wide, without bulblets, 10–54 flowered; pedicels 8.5–20.2 mm long; bracts 9.3–19.7 mm long. Perianth stellate, deep pink, with reddish midveins, inner tepals unequal to outer ones, elliptical-lanceolate, acute at apex, 7.2–7.7 mm long, 2.3–3.5 mm wide; outer tepals elliptical, acute at apex, 6.0–6.2 mm long, 2.8–3.0 mm wide; filaments exerted (outer) or not (inner), 7.0–7.5 mm long; anthers 2.0–2.4 mm long; ovary subglobose, with crest-like appendages at apex, 2.7–3.2 mm long, 3.0–4.0 mm wide; style exerted. Capsules cordiform, 4.0–5.0 mm long, 4.1–5.0 mm wide. Seeds oval, semicircular in cross-section, 2.5–3.3 mm long, 1.5–2.2 mm wide.

Phenology: Flowering from July to September.

Distribution: North America.

SK: Open plains and wooded areas of central-eastern to south-eastern parts (Fig. 1D).

Remarks: This species is widely distributed and relatively common in the prairies and adjacent boreal plains of south-eastern SK. Its closely related species, *A. cernuum*, occurs allopatrically in the boreal shield areas of two isolated areas (Cypress Hills and Meadow Lake) of SK (Fig. 1C, D).

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# ENVIRONMENT

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## MANAGING ENVIRONMENTAL UNCERTAINTY

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### Introduction

Environmental management is a rapidly advancing application of science, especially ecology. In recent years, the science of uncertainty has begun to have important implications for environmental management practices, especially in a place with as much development and as many ecological tension zones as there are in western Canada. A read of recent literature on the potential effects of an expanding human population and technology on global climate is enough to convince even the most sceptical that uncertainty is very real in nature, and that it is of concern to individuals and administrations everywhere.

What are some of the environmental uncertainties in Canada's prairie provinces, viz. Manitoba, Saskatchewan, and Alberta? First, the amount of annual precipitation in the southern half of these provinces is less than in other parts of Canada, and it is also less certain.<sup>1</sup> Droughts and floods occur at unpredictable intervals. Next, ecotones between major ecosystems are places of even more uncertainty due to potential boundary relocation. Human activity also is a great contributor to uncertainty as development proceeds northward and changes continually in already developed areas. Finally, the spectre of long-term climate change causes further uncertainty within already existing uncertainties.<sup>2</sup>

In this paper, I address the nature of uncertainty in the environment, apply this

to Canada's prairie provinces, and suggest ways in which society can continue to use resources and adapt itself to inherently uncertain ecological processes without destroying them.

### Role of Uncertainty in Nature

The noted ecologist and historian of ecology Frank Benjamin Golley<sup>3</sup> agrees with Daniel Simberloff<sup>4</sup> that "ecological systems are stochastic and indeterminate...and that the history of science is a dialectical opposition between determinism and indeterminism." This comment represents a change in life view assumptions that has affected science in the latter years of the twentieth century, namely, the recognition of uncertainty as an important constituent of natural processes, and the search for the role of uncertainty in these processes. The new approach has added to the search for regularities or certainties in nature fitting into the assumption that we could eventually know everything about nature and then be able to predict events with accuracy, and even control them to our human benefit.<sup>5</sup> This old assumption fits neatly with the also old belief that nature consists of natural resources, which exist primarily for our human benefit, and all that we have to do is to find them and exploit them.<sup>6,7</sup> Now we know better, and we are beginning to shed some of our past hubris regarding nature, our view of which has led us to make it less predictable even while we have been trying to increase resource predictability.





*Eastern parkland, Cook's Creek, southeastern Manitoba.*

*Henry Epp*

The acknowledgment and study of uncertainty in nature did not arise suddenly, but grew gradually as the twentieth century progressed. The ecosystem concept in ecology helped steer the thoughts of biologists to the need to incorporate uncertainty into explanations and predictions, as it became necessary to factor in the intuitively unpredictable weather and climate influences.<sup>3,8,9</sup> Older ecosystem models focused on ecological succession and thermodynamics, the ultimate state being energy equilibrium, a continual recycling of energy. Newer models incorporate the role of uncertainty in process operations.<sup>7</sup>

A brief definition of the ecosystem concept is in order. The comprehensive definition by Higgashi and Burns<sup>10</sup> incorporates Odum's<sup>8</sup> older definition: an "ecosystem is a physical entity: a *dynamical system* consisting of a biological entity, typically a regional biota (community), together with the environment." This definition requires further definition of what a system is and, especially, what a dynamical system is. Simply put, a system is a set of relationships among objects and their attributes within their environment.<sup>11</sup> A

system, then, is a discrete and active entity in which complex actions take place, an entity that is more than the sum of its parts, a synergism. A dynamical system is one in which no system state is ever exactly like the one preceding it, meaning that it is subject to continual and permanent change. The identification of permanent change as inherent in an ecosystem leads logically to identifying the role of uncertainty in ecosystems. Ecosystems tend not to behave dynamically most of the time. Usually, an ecosystem behaves as an adaptive system, which adjusts or adapts its functions to return to normal near equilibrium following minor disturbance. Dynamical, non-repetitive changes usually do not occur until the no-return process threshold in disturbance tolerance is exceeded in any specific instance. This ecosystem trait makes identification of tolerance thresholds very important in ecosystem management.

The uncertainty in ecosystems is rooted in the uncertainty inherent in all physical and chemical systems. Uncertainty was of no small concern to physics during the first half of the twentieth century as physicists struggled to cope with quantum theory.<sup>12</sup> During the 1960s, the study of



uncertainty received a huge boost by the discovery of rules of unpredictability in climate by Edward Lorenz,<sup>13</sup> which later became the basis for chaos-complexity theory.<sup>14</sup> After a brief time in the media limelight, chaos theory settled back into being part of a more comprehensive self-organization theory.<sup>15</sup>

How do systems subject to self-organization influences actually work? Complex systems have parameters, a condition in our universe which is not yet at entropy, the ultimate random equilibrium predicted by the second law of thermodynamics.<sup>12</sup> "Parameters are functions of the distribution generating the data,"<sup>16</sup> causing non-random clumping of information in a system not at entropy. The answer lies in the strange form of certainty that is always present in uncertainty. No system falls from organization into total disarray. Rather, there is always an ordered process leading to disorder, at which time potentially new system orders appear in profusion, and then there is an orderly return to order. Only one or a few of these potentials can survive after the others are out-competed, and then it

arises from the mess as a new system order, self-organization. The new order, however, is never entirely predictable from the state of the old order.

Ecosystems are subject to the rules of self-organization as are other systems, and the lesson to environmental management here is twofold: (1) the change process is evolutionary, due to a natural, undirected, selection from possibilities, so that once a selection has occurred, there is no turning back; (2) maintenance of order in an ecosystem is underlain by the disorder that always lies in the background, causing variation, providing uncertainty a very important role in ecosystem maintenance as it generates new system orders from which selection from among new possibilities then proceeds in an environment that restricts possibilities due to parameters or boundaries. Hence, ecosystems are non-linear systems, seldom in complete equilibrium.<sup>7,17</sup>

Non-linear systems are never quite balanced. This fact may surprise those who are used to thinking of a wilderness



*Foothills, Elbow River, southwestern Alberta.*

*Henry Epp*



environment as being in balance (the “balance of nature”). Balance or equilibrium does occur, but it is always unstable and subject to disequilibrium upon disturbance. Permanent change or evolution would not occur at all or proceed exceedingly slowly in a permanently balanced ecosystem. The well known evolutionary speed race between the cheetah and the gazelle, for example, would cease if the balance between the two species was stable over a long period of time.

Having established that uncertainty is ubiquitous in nature, and that it contributes to variation in ecosystems by enabling potentially new system orders, an important function of uncertainty in an ecosystem, then, is to improve the certainty of recovery given serious disruption. This sounds contradictory, that uncertainty underlies certainty, but the concept is central to self-organization.

## **Environmental Management Implications**

A prominent environmental management assumption holds that it is important to maintain ecosystem processes, thereby maintaining ecological integrity.<sup>17–19</sup> Yet, conserving processes is not the same as maintaining an ecological status quo. Ecosystem change is normal and natural and to be expected, but unusually severe disturbance can push processes over the edge of recovery and trigger a chaotic interval, following which there may be re-establishment of order, but the new order will not be predictable. Processes have thresholds of tolerance of disturbance, and identifying these is useful to ecosystem management. An example of where a process threshold is important is a place where ungulate populations are regulated by predators, as is the case in the Ngorongoro crater in Tanzania, where several predator species prey on ungulates.<sup>20</sup> The predators

include lions, spotted hyenas, leopards, cheetahs, and wild dogs. Removing one predatory species would be unlikely to cause huge increases in prey populations, but removing them all certainly would do so. Obviously, removing predator species one by one eventually would result in exceeding a tipping point or threshold, and prey population regulation would cease. North American equivalents to Ngorongoro involving a suite of large mammalian predators no longer exist, due to massive human interference with predator–prey relationships.

Not all ecological processes include regulatory or balancing actions. An example of an ecosystem in which ungulate populations are not regulated by predators is one in which annual migration events occur.<sup>20</sup> The Serengeti-Mara ecosystem in Kenya and Tanzania is one such case, another is the tundra-taiga ecosystem in northern Canada with its migratory caribou populations, and a third is the former North American plains ecosystem with its migrant bison herds.<sup>20–22</sup> In all of these ecosystems, ungulates are or were not regulated by predators, but by food supply or other influences.<sup>20</sup>

Why do migratory prey populations tend to elude regulation by predators? The answer is simple enough, explained thoroughly by Fryxell et al.<sup>20</sup> Migrant ungulates are either non-territorial or only partially so, but most predators are territorial, with individuals capable of only very limited travel beyond defended territories. This means that at least once a year, for months on end, most predators are limited to resident prey. These residents tend to be either territorial, dispersed over their terrain, not clumped, or resident populations of non-territorial species; while the latter do exist, they are unlikely to comprise more than 10% of the total population of a species in

a defined ecosystem.<sup>20</sup> Hence, most predator populations are limited to those that are able to survive on resident prey, leaving the migrant prey to swarm outside of regulation by predation. This information is very important to game managers, as migrant populations are capable of sustaining a much higher human harvest rate than are residents. A difficulty with management, however, is that prey populations that are not regulated by predators are subject to greater unpredictable fluctuations in numbers than are regulated populations, so that human harvest can never be consistent over long time stretches. Migratory caribou are notoriously subject to such population fluctuations.<sup>23</sup>

The biological literature links uninterrupted functioning of ecological processes with maintenance of biodiversity.<sup>24,25</sup> Hence, the environmental management literature is full of the virtues of biodiversity. Managers frequently actively seek out for protection those parts of ecosystems with the greatest biological variability. Why? The answer lies in that those parts of ecosystems with the highest levels of variability often are the least severely affected by outside disturbances, including human activities. Ecological processes and ecosystems with high levels of variability tend to be more resilient to outside disturbance than are those with low levels of variability.<sup>24,26</sup> However, recent research in Switzerland indicates that this is not a rule that applies to all ecological processes equally, specifically plant growth reaction to drought.<sup>27</sup> Contrary to expectations, “species-poor systems” may be more resilient to drought than are “species-rich systems.” Yet, even more recent research in aquatic ecosystems has shown that habitat or spatial heterogeneity and “disturbance regimes” are important ecological characteristics that contribute to system resilience.<sup>28</sup> This situation

holds true especially in ecosystems with predator–prey processes, which were not included in the Swiss research.

Clearly, ecological diversity contributes to resilience to disturbance, even if predictability of such resilience is less than 100%. Complicating matters, disturbance also contributes to the very diversity which provides resilience to it.<sup>29</sup> Recognizing such interconnectivity of processes is important to environmental managers striving to maintain ecosystem processes.

Also important to environmental management is the fact that ecosystems normally operate as adaptive systems as defined by Harvey,<sup>11</sup> not as dynamical systems, returning to more or less the original state of operation following recovery from minor disturbances. Recovery from disturbance is an old ecological theme, involving succession and energy transfers.<sup>7</sup> Ecological process thresholds are important here; if a threshold is exceeded by a disturbance, dynamical activity may ensue, with uncertainty ruling.<sup>30</sup> The only certainty then is that a new system order will eventually re-establish itself, but its nature will be unpredictable. No environmental management organization desires to cope with the unpredictability of an ecosystem gone dynamical. A diverse ecosystem has more potential system process pathways upon which natural selection acts once process thresholds are exceeded, than does a monoculture ecosystem, for example. Ecological collapse of monocultures is an ever present agricultural management problem,<sup>31</sup> an event much less likely to occur in varied ecosystems. Hence the management emphasis tends to be on maintaining biodiversity.

Interestingly, it is not ecological equilibrium that generates the biodiversity



needed to maintain that very equilibrium, but disturbance and heterogeneity. A management implication is almost counterintuitive, that ecosystems should not be protected from all disturbances. Uncertainty science teaches us that if the equilibrium–disturbance threshold is exceeded, the ecosystem will enter a chaotic interval which severely reduces predictability of outcome. The answer is to maintain some disturbance but not so much that it exceeds process thresholds. Human disturbances should emulate natural ones, which tend to be sporadic, not continual, usually not exceeding tolerance thresholds. Resilience lies partly in the uncertainty of natural disturbances, and less so in the certainty of either continuous human disturbance or protection from outside influences. Research to establish process thresholds is therefore essential.

How can we maintain biodiversity in the face of increasing development pressures? A common approach is to seek out for protection the most diverse areas, i.e., ecosystems ‘hot spots.’<sup>32</sup> These need to be protected from intensive development, allowing some human activities in the least diverse areas. The population of any particular species within an ecosystem is not distributed uniformly over its habitat. Ecologists identify ‘source’ and ‘sink’ habitats.<sup>33,34</sup> A source habitat is the area in which the ecological niche of the species is at its best, enabling potential population gain. A sink habitat is an area occupied by a species, but in which the ecological niche is poor enough so that there is overall loss in numbers. This means that specific populations in sink areas are maintained only when there is overflow from source areas.

Source and sink effects create a difficulty for the environmental manager. The most biologically diverse areas frequently are ecotones, the zones of

overlap between major ecosystems or ecozones. In the prairie provinces, the most important ecotone is the aspen parkland, the border zone between the prairie grasslands to the south and the boreal forest to the north.<sup>35,36</sup> Both boreal forest and prairie species spill over into this ecotone from their respective ecozones. This creates an edge effect, a zone of high species diversity.<sup>8,33,37</sup> While ecological edges are places of high biodiversity, this fact can create a false confidence in promoting such places for preservation in lieu of protecting less diverse source areas. Not all, even carefully researched, environmental management recommendations and plans recognize this management conundrum. While complex ecosystems tend to be more resilient to disturbance than simpler ones, it is more hubris than ecological science to promote edge areas for protection to the exclusion of core source environments. Protecting sink habitats alone hints at a false confidence in maintaining biodiversity. In any edge area, a slight climatic change will favour one ecosystem over the other, worsening the source effect for the species of the receding ecosystem, an uncertainty that is certain. Yet it is also important to protect the areas of uncertainty because the secret of sound ecosystem management is not to maintain stability or balance, but to maintain resilience. Resilience relies on the presence of variation, which itself is supported by the presence of uncertainty. Hence, while biodiversity is an overall guide to what needs protection, maintaining ecological process stability requires a judicious choice of diverse areas in *both* source habitats and ecotones. Moreover, equally important to attain this end is a variable protection plan, one that continually identifies sensitive and resilient areas as they change with climatic variance and human disturbance. The plan then moves to protect the

parts of ecosystems required for overall process maintenance, which is underlain by resilience. Clearly, some sites should be protected permanently, but large areas change quickly enough that different parts may need to be protected at different times. Environmental management needs to adjust its methods to ecosystem process changes in any particular place under such management. Holling has called this “adaptive management”.<sup>38</sup>

### **Loci of Uncertainty in Prairie Environments**

Environmental uncertainties can be classified according to whether they are natural or anthropogenic (human-caused) in origin. Environmental uncertainty has three major effects on ecosystems: (1) increased genetic and process variation, enhancing resilience to disturbance, (2) instances of disequilibrium, such as population swarms, and sudden population losses in some species, and (3) zonal boundary shifts due to climate change. While all of these effects can be considered neutral in a natural ecosystem, humans alter ecosystems to ensure certainty of resources for themselves. Human-caused uncertainties can influence all three effects, so that excessive resource use is likely to push uncertainties over their resilience thresholds and cause further, often uncontrollable, uncertainties. This has already happened in the prairie grasslands ecosystem, where cultivation and overgrazing exceeded the process thresholds long ago. The dominant agricultural ecosystem that has replaced the natural one has become fairly stable as technology has improved, but its resilience remains very shaky and is easily upset by droughts, pest swarms, loss of genetic variability, and continued nutrient depletion.<sup>39</sup> Actions to increase the certainty of economic gains have created new uncertainties that scientists have not altogether learned how to

cope with, at least not when climatic uncertainties increase. The story of the destruction of the original grasslands ecosystem in western Canada and its agricultural replacement is well known,<sup>19</sup> and will not be discussed here.

The aspen parkland ecotone has fared no better than the grasslands with regard to agricultural development,<sup>35</sup> except that aspen stands remain fairly abundant over most of the range. The boreal forest to the north has not yet fared as badly as the grasslands and parklands, but clearcutting remains an important economic pursuit. The saving grace to date has been regulation by governments to restrict the size and shape of clearcuts, so that at least a rough simulation of natural fire disruption has been attained, although not everywhere.<sup>40</sup>

During the last years of the twentieth century and the first few years of the twenty-first century, an ecologically disruptive force that has received the most public attention has been the potential of climate change, viz. global warming caused by anthropogenic release of greenhouse gases. The most important source of information on global warming available at this time is the Intergovernmental Panel on Climate Change (IPCC). IPCC predicts a maximum temperature increase for the year 2100 of from 2 to 4.5°C, predicting equilibrium at an increase of about 3°C.<sup>41</sup>

The purpose here is not to debate the accuracy of the IPCC predictions, which are part of an intense public controversy at this time, but to relate the predictions to environmental management implications in Canada's prairie provinces. What would be the effects of an increase of 3°C in about 100 years? Important clues can be inferred from known past climate changes, so, while climate change



remains highly unpredictable, reasonably accurate ecozone shift scenarios are possible given input of estimated climatic conditions. Interestingly, about 6000 years ago, North America was 2–5°C warmer than it is now, and the grasslands ecosystem was pushed northward by about 300 km.<sup>42</sup> Hence, it is reasonable to predict that a similar shift would begin to occur in about 100 years if anthropogenic warming peaks according to the IPCC prediction.

An important implication of a warming of 3°C to the agricultural belt, the grassland ecozone, and the parkland ecotone in western Canada, is a likely increase in aridity.<sup>41,43</sup> This would require a major change in usage. Such a shift in usage has already been anticipated by the Alberta Government for the South Saskatchewan River watershed, where new regulations apply as “the limit of the water resource has been nearly reached”.<sup>44</sup> The boreal forest southern boundary would move northward, substantially reducing the area of commercial forest, but the northern boundary would also shift northward, taiga moving into what is now tundra. Lakes in the boreal forest would begin to dry up as they are mostly glacial relicts and could not sustain their present levels.<sup>45</sup> The aspen parkland ecotone would move northward as well, and could expand to engulf as much as one-half of western Canada’s boreal forest.<sup>43</sup> Urban centres in the south would have to adjust water usage, as glacial meltwater runoff from the mountains likely would end, causing very low summer flows in prairie rivers.

The scenario described above is a worst case one, so the actual environmental changes a century from now are likely to be less extensive. The nature of the ecological changes is reasonably predictable, namely northward

movement of the parkland and taiga-tundra ecotones.

## **Conclusions and Management Implications**

Environmental uncertainties in the prairie provinces are both naturally and anthropogenically caused. The weather is predictable only for about 5 days,<sup>13</sup> and climate is predictable only broadly by seasons and by the long-term effects of release of greenhouse gases into the atmosphere by humans burning fossil fuels. Ecosystem boundaries, including the aspen parkland, are zones of higher natural unpredictability than are core ecosystem areas. Both natural and human-caused disturbances to ecosystems increase process unpredictability.

A conclusion derivable from the science of uncertainty in nature is that the environmental manager should not try to manage for the entire range of potential uncertainties, as this would waste energy and would be futile. Some uncertainties are useful to the manager as they help to maintain ecosystem resilience in the face of disturbances such as the predicted anthropogenically caused climate change, and these uncertainties should be identified. A danger is ever present, however, that some disturbances could tip an ecological process over its resilience threshold, initiating a chaotic interval that would result in a permanently and unpredictably altered process. Such a situation creates so high a level of uncertainty that management becomes impossible, which is not a desired condition for a manager.

The science of uncertainty applied to ecology enables the environmental manager to address some former management uncertainties and fears. These are improved selection of sites for protection, improved selection of sites for

adaptive management, which includes site location changes over time, and research needs to determine ecological process thresholds as they apply to management areas. A new fear is the now recognized inability to accurately predict ecosystem changes that will occur after excessive human resource use in an area exceeds the threshold of the ability of the ecological processes to adapt to the changes and recover from them.

One very clear conclusion that emerges from applying uncertainty science to environmental management is that research to provide reasonably accurate estimates of disturbance thresholds of ecological processes is essential. This research needs to address both ecosystem-specific and site-specific processes over all ecozones and the ecotones in between. Once thresholds are known, it is possible to manage disturbances by setting limits and regulating human activities that cause the disturbances. Managing environmental uncertainty means managing both for maintaining some uncertainties and for limiting others, and knowing which is which. At this time we know we need to do this, but we are nowhere near having all the knowledge required to do it properly.

## Acknowledgements

This paper has benefited from comments by the editors and an anonymous reviewer.

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# NOTES AND LETTERS

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## GREAT BLUE HERON SWALLOWS MUSKRAT

The great blue heron (*Ardea herodias*) consumes a variety of small animals. Some of its larger prey include large fish, frogs, salamanders, lizards, snakes, young rats, pocket gophers, and ground squirrels. On occasion, rails and phalaropes are killed and eaten by herons.<sup>1</sup> An impressive sequence of photographs of a large heron drowning and swallowing a Richardson's ground squirrel (*Urocitellus richardsonii*) was presented by Sykes (1996).<sup>2</sup>

"Tanneroon Swamp" is my name for a 20 ha swale through which Jackfish Creek meanders 1.6 km south from Moon Lake to Tanner Lake in the northern sector of Riding Mountain National Park, Manitoba. P.T.H. 10 passes near a beaver-created pond on the NE side of the swale, then curves westward just south of Moon Lake. An old beaver lodge lies near the S edge on the pond about 75 m west of the highway.

On 23 June 2006, a great blue heron stood in the water NW of and 3 m from the beaver lodge. I first saw the heron as it turned and slowly walked away from me. Shortly thereafter, it turned and followed the edge of the old beaver dam, providing a side view. Protruding from its bill was the posterior portion of a furry animal, its hind legs and tail dangling down. Anticipating its flight at any second, identification of the prey took precedence over photography, and in the ensuing 30 to 40 sec before it flew NW, the bilaterally compressed tail, hind leg traits, and its brown fur - as noted through 7 × 35 binoculars - left no doubt that the prey was a muskrat (*Ondatra zibethica*).

The heron flew WNW some 250 m and alighted at the edge of Jackfish Creek,

about 60 m south of the west end of the highway curve. In less than 1 min, I drove around the curve in time to see the large bulge in the bird's neck, the muskrat having been swallowed. After a minute or so, the heron took a drink from the creek, presumably to facilitate the swallowing process.

I used the heron's bill as a 'measuring stick' against which parts of the muskrat could be estimated. The culmen of the big marsh bird averages about 14.3 cm.<sup>3</sup> The head and both front legs of the muskrat were out of sight in the heron's throat. Thus the distance from just back of the front legs (the base of the heron's bill) to the tip of the snout was estimated to be 9 cm, with the upper mandible reaching to within 6 cm of the posterior of the body. The 16 cm long tail gave an estimated total length of approximately 45 cm.

In Canada, the average total length of adult male and female muskrats is 57.3 and 56.1 cm, respectively.<sup>4</sup> In Manitoba, young muskrats are born about mid-May and are on their own in 1 month.<sup>4</sup> Was 45 cm a reasonable total length for a juvenile muskrat for 23 June? Probably. On 27 May 1985, my class of biology students had watched in amazement from near, and on, another beaver dam a few km from this location. A mother muskrat had swum 50 cm below the surface and within 1.5 m of us as it dragged four young along by their mouths holding on to her teats. These young showed coarse, sooty hair which aged them at 5 to 15 days.<sup>4</sup> Their estimated total length was 20 cm.<sup>5</sup> This was 35% of that of an adult. At 45 cm, the 23 June 2006 muskrat was believed to be 80% full length.



On 24 June, another great blue heron, possibly the same individual, was seen exactly where I had observed it the day before: some 3 m WNW of the edge of the old beaver lodge. Poised, it was ready to strike precisely where the muskrats had been seen emerging from the lodge earlier in the spring. With my arrival, the heron soon flew off. Within seconds of its departure, a sub-adult muskrat emerged from the dense sedge (*Carex* sp.) and swam directly toward the beaver lodge and dived at the spot that had been the heron's point of interest. Subsequent brief stops at the area throughout the summer produced no more sightings of the heron or muskrats. Could this heron have found these aquatic rodents, siblings or otherwise, to make "filling" meals - and wiped out an entire complement of young?

## UNUSUAL LILY

On my farm I have native prairie upon which I have a conservation easement. During the growing season it is certainly a pleasure to walk the area at various times to view the plants and animals. Very late in June 2009, I found a Saskatchewan floral emblem area. Within this area was one bloom that stood out: It was most perfect with its seven flower petals. I know they are to have only six. I got my disposable camera and took various photos that Saturday. On Monday, family came for a visit, and I took them out to view the various flowers. I went to show them my seven-petalled lily. Alas,

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- William J. Walley, 222 Bossons Ave.,  
Dauphin, MB, R7N 0R2

something (perhaps a deer) had eaten that flower. No others - just my seven-petalled flower. It was truly beautiful to see and photograph. What are the odds of a SEVEN-petalled lily?

- Delwyn J. J. Jansen, Four 20 Farm, Box 161, LeRoy, SK, S0K 2P0

**EDITORS' NOTE:** Unfortunately, the photo submitted with this letter was not of print quality. However, for another unusual lily, see the photo by Sarah Vinge on the inside back cover of this issue.



*There is a way that nature speaks, that land speaks. Most of the time we are simply not patient enough, quiet enough, to pay attention to the story.*

- Linda Hogan

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# PHOTO NOTES

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## JUMPING SPIDER



On 20 June 2009, I was scouting along the edge of a bog 14 km south of Creighton, SK, looking for long-jawed orb weavers to photograph. Meanwhile, my wife, Brenda, was checking out the few stunted trees, blueberries, and bog cranberries on the rocky outcrop. She spotted a spider on a fallen black spruce and called me over. I knew it was a jumping spider by its eye arrangement and its calm nature, but its large size and the buff-orange colour of its abdomen were unlike anything I'd seen before. Its abdominal markings blended in exceptionally well with the bark.

I quickly took pictures of it as I knew I'd need help with identification and used a ruler to get a rough size. It was between 10 and 15 mm long. When we got home, I uploaded a couple images to BugGuide, one of the many online resources for identification (<<http://bugguide.net>>; I also use <[www.SpiderIdentification.org](http://www.SpiderIdentification.org)>). There you will find entries from entomologists and naturalists who are committed to building an online knowledge base.

A discussion broke out on BugGuide as to whether the spider was *Phidippus borealis* or *P. purpuratus*. According to range maps referenced on BugGuide, both are native to Saskatchewan, with the range of *P. borealis* actually extending right up through the Northwest Territories and the Yukon as far as Old Crow. *P.*

*purpuratus*, on the other hand, is a more southern species, found in eastern Canada and the lower 48 states. On the map, the northern extent of its range in Saskatchewan is along the Canada–US border. As the discussion went on, the participants were leaning more to *P. borealis*, since specimens have been collected in Saskatchewan as far north as the NWT border; however, the only way to get a positive ID would be to capture the spider, preserve it in alcohol, and send it to someone who could examine its genitalia. I didn't want to do that. I was just thrilled that I got to see and photograph one of the largest jumping spiders in Saskatchewan.

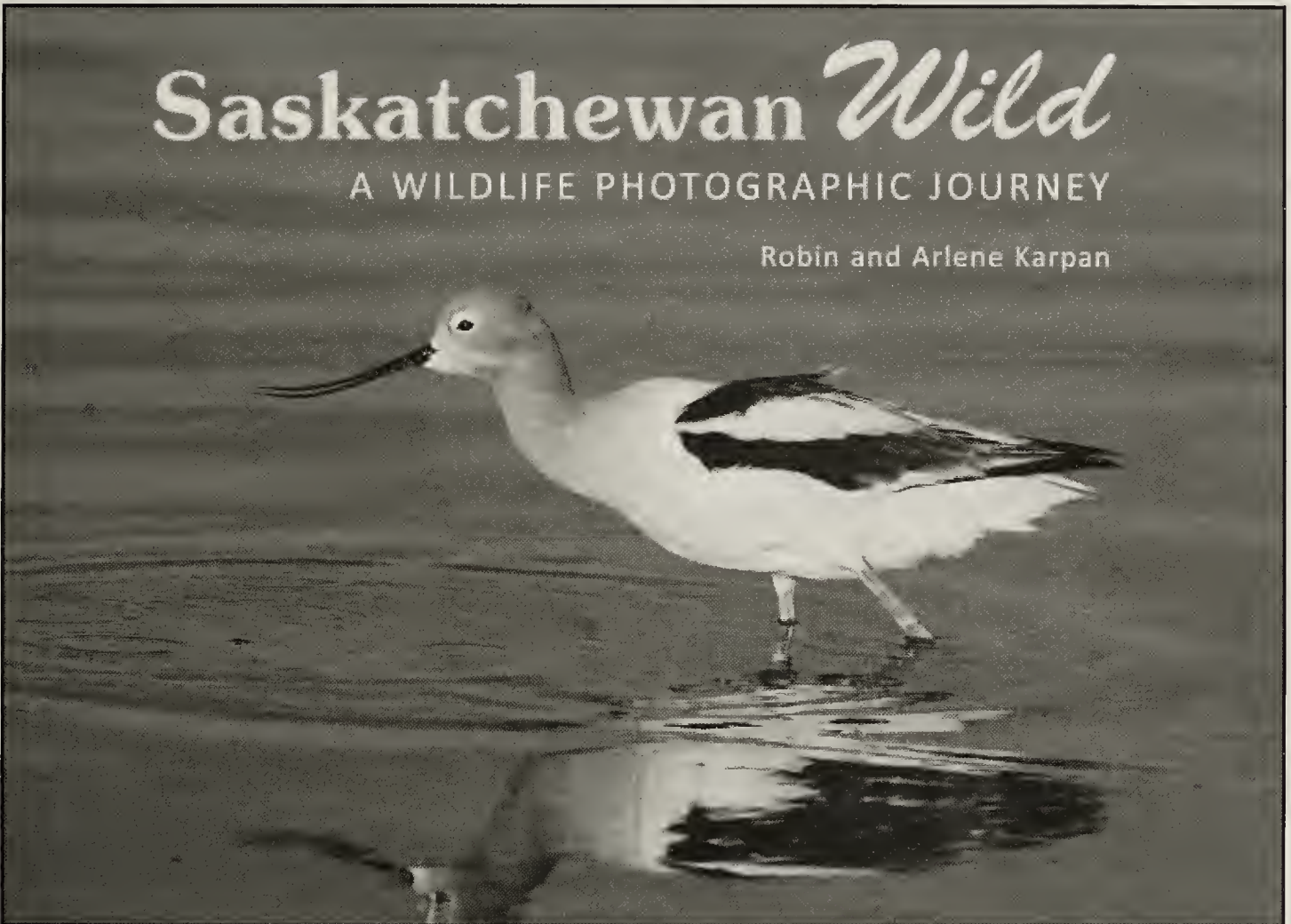
- Harvey Schmidt, Creighton, SK

**EDITORS' NOTE:** For a different (colour) view of this jumping spider, see the outside back cover, and for more of Harvey Schmidt's fascinating photography, please visit his blog site at <<http://spiders-n-stuff.blogspot.com/>>



# SASKATCHEWAN WILD: A WILDLIFE PHOTOGRAPHIC JOURNEY

Robin and Arlene Karpan. 2010. Parkland Publishing. Saskatoon, SK. \$34.95 CDN. Hardcover. ISBN: 978-09809419-1-3. 128 pages. 183 colour photos. 27.8 cm by 21.5 cm.



*Saskatchewan Wild* is a coffee-table book of Saskatchewan wildlife photographs by award-winning Saskatoon authors and photographers Robin and Arlene Karpan. It is not a field guide. The authors bill the book as 'a personal photographic journey, a taste of the many wildlife adventures possible in Saskatchewan'. They hope this book can play a role in fostering appreciation for nature and ultimately better protection for wild places and wildlife in Saskatchewan.

The book is divided into five sections of varying lengths: birds, mammals,

butterflies, wildflowers, and fall colours. About 60% of the book focuses on avifauna of the province, with an emphasis on waterfowl and shorebirds. Other types of birds in the book include commonly seen songbirds, common diurnal birds of prey, woodpeckers, hummingbirds, and grouse and pheasants. I was pleased to see several endangered species such as the piping plover, burrowing owl, and greater sage grouse and a discussion of their plight included in this book.

The mammal section is relatively small, with a focus on some commonly seen

species such as white-tailed deer, mule deer, pronghorn antelope, moose, elk, black bear, wolf, coyote, red fox, badger, Richardson's ground squirrel, and black-tailed prairie dog. Some notable mammals that were missing from the book included cougar, beaver, mink, swift fox, and red and gray squirrels. Only two pages were devoted to butterflies and none to other insects, invertebrates, amphibians, or reptiles. The wildflower section was larger and represented a good sampling of upland wildflowers. However, only two pages were devoted to wetland plants. The final section focused on fall colours found across the province.

The book is attractively laid out. The photos are clear and sharp, and most of them are spectacular. The photos are accompanied by well researched and well written short commentaries reviewed by local experts. The book concludes with useful contact information and online links to 14 agencies and organizations that focus on Saskatchewan wildlife, as well as a plug for the Karpans' other books about Saskatchewan.

It must have been a significant challenge for the authors to select species and photos for a book limited to only 128 pages. The authors could have easily created a coffee-table book for each group: birds, mammals, butterflies, wildflowers, and fall colours.

This book definitely renewed my appetite for Saskatchewan wildlife, and it succeeds as a wildlife photographic journey that fosters greater appreciation of nature. I recommend this book to anyone interested in Saskatchewan wildlife.

*Reviewed by Rob Warnock, E-mail: warnockr@accesscomm.ca*

**EDITORS' NOTE:** For more information about this book and to see sample pages, visit the publisher's website at: <<http://www.parklandpublishing.com/wild/sample.pdf>>



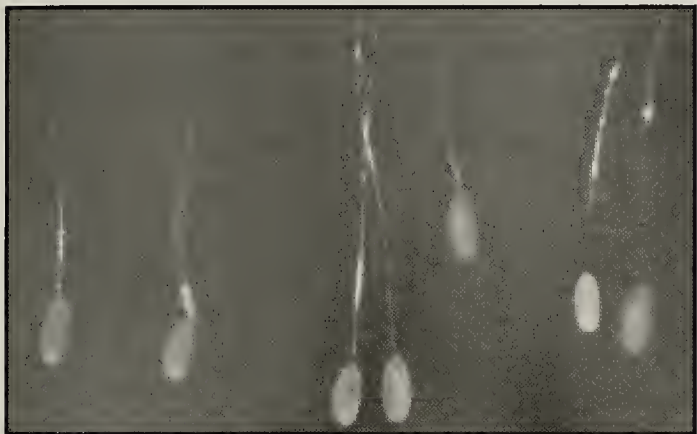
*Black-necked stilt (Himantopus mexicanus).*

*Randy McCulloch*



# MYSTERY PHOTO

## ANSWER TO THE JUNE 2010 MYSTERY PHOTO



Via e-mail, Brenda Lepitzki submitted the following solution to our June mystery: “The tiny gems suspended from a willow twig that Harvey Schmidt found look like the eggs of the neuropterans commonly known as green lacewings (family Chrysopidae). These beautiful insects have green bodies and large greenish or clear wings full of veins, and golden or bronze eyes. He’s lucky to have them around as they are predators of aphids and mealybugs. It is thought that

the long thin stalks the eggs hang from deter their predators.”

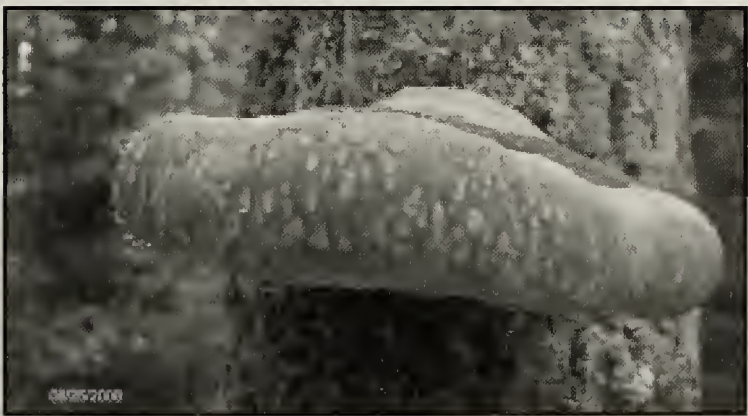
It seems that Brenda’s answer was bang on – here’s what photographer Harvey Schmidt had to say about his unusual subject matter: “In the summer when you see a delicate-looking bug fluttering about it’s probably a green lacewing. Sometimes if you’re lucky they will land on you. I found this one [see photo below, left] flying over the lawn back in June. The weather was pretty strange this summer [2009] but there seemed to be a more than normal amount of them in our yard. One day, while filling the bird feeder, I noticed tiny lacewing eggs hanging from a willow twig. I wasn’t lucky enough to see them hatch, but I did manage to find one of the larvae [see photo below, right].”



*Green lacewing: adult (left) and larva (right).*

*Harvey Schmidt*

## SEPTEMBER 2010 MYSTERY PHOTO



Joseph Kotlar submitted this photo for potential identification. He writes: “This fungus was observed by two fun guys hiking in Prince Albert National Park, SK. Does anyone know the name of this fungus?” Who’s up for the challenge?



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Common names are used for birds, mammals, butterflies, reptiles and amphibians. Bird names follow the Checklist of North American Birds by the American Ornithologists' Union (7th edition, 1998); mammal names, Mammal Species of the World by Wilson and Reeder; butterfly names, The Butterflies of Canada by Layberry et al; and names of reptiles and amphibians follow Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico by Brian I. Crother, Committee Chair (2001), <<http://www.ssarherps.org/pdf/Crother.pdf>>. For other groups, both scientific and common names are included.

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## Blue Jay





Figure 4. Male lazuli bunting (*Passerina amoena*) southeast of Lyleton, Manitoba, 30 July 2010. See article by Artuso et al. on p. 114.

Christian Artuso



Unusual western red lily (*Lilium philadelphicum* var. *andinum*), spotted in July 2010 in the Coteau Hills, SK, with four petals, four sepals, seven fertile stamens and one stunted, infertile stamen.

Sarah Vinge, Nature Saskatchewan





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